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OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

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MEMORANDUM

SUBJECT: Revised Addendum to Ecological Risk Assessment for the Isoxaflutole Proposed Section 3 Registration for Use on Soybeans

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In 2011, EFED completed an ecological risk assessment of the proposed new use of isoxaflutole on soybeans (DP barcodes D382797, D382708). This assessment relied primarily upon the results of a 2010 assessment of an Experimental Use Permit request for soybeans. The 2010 and 2011 assessments concluded that isoxaflutole posed a risk to non-target plants exposed to isoxaflutole through runoff and spray drift transport.

The attached refined risk assessment focuses on the risks of isoxaflutole to non-target plants. This assessment uses multiple lines of evidence to evaluate the risks of isoxaflutole to non-target plants. This assessment does not rely upon risk quotients that are derived from the most sensitive endpoints, but rather a comparison of data available from multiple test species to different exposure estimates. Exposure estimates for drift are based on both AgDRIFT calculations as well as registrant submitted study focused on deposition of isoxaflutole (formulated as Balance). Exposure estimates for runoff are based on TerrPlant. Additional lines of evidence used to characterize potential risks from runoff include the provisional model, Audrey III, as well as a runoff study involving isoxaflutole.

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This assessment concludes that spray drift deposition poses a risk of decreases in growth for dicot plants that are located at distances that are hundreds of feet from the field. Runoff exposure also poses a risk to plants located adjacent to the treated field. There are substantial concerns for impacts to the integrity of plant communities, and species which depend upon plants for food and shelter. There is risk of direct effects to federally-listed endangered and threatened species of plants located within hundreds of feet from the edge of the field and risk of indirect effects to listed animals that depend upon plants. A "may affect" determination is made for 352 listed species based on concerns of direct effects to 96 listed species of plants and 256 listed species of animals.

This addendum was revised to correct an error in the characterization of the risks due to spray drift considering the registrant submitted spray drift study for isoxaflutole. This document replaces the addendum finalized on 4/22/16.

Contents

Introduction

Isoxaflutole is an herbicide used to control a wide range of grass and broadleaf weeds. This chemical is applied via ground equipment at pre-plant, pre emergence and post emergence of the crop. Isoxaflutole is currently registered for use on corn at a rate of 0.094 lb a.i./A. The current registration is limited to 26 states; however, the registrant has requested that the use be expanded into an additional 5 states (**Table 1**). The focus of this assessment is on the proposed new use of isoxaflutole on genetically modified soybeans. The proposed registration would be limited to the same 26 states in which corn is currently registered. Although there are several registered formulated products containing isoxaflutole, this assessment focuses on Balance Pro herbicide, since this is the only product proposed for use on soybeans.

Table 1. Current and proposed states for use of isoxaflutole on corn and soybean.

State	Registered for corn?	Proposed use on soybean?
Alabama	Yes	Yes
Alaska	No	No
Arizona	No	No
Arkansas	Yes	Yes
California	No	No
Colorado	Yes	Yes
Connecticut	No	No
Delaware	Pending	No
Florida	No	No
Georgia	Yes	Yes
Hawaii	No	No
Idaho	No	No
Illinois	Yes	Yes
Indiana	Yes	Yes
Iowa	Yes	Yes
Kansas	Yes	Yes
Kentucky	Yes	Yes
Louisiana	Yes	Yes
Maine	No	No
Maryland	Pending	No
Massachusetts	No	No
Michigan	Pending	No
Minnesota	Pending	No
Mississippi	Yes	Yes
Missouri	Yes	Yes
Montana	Yes	Yes
Nebraska	Yes	Yes
Nevada	No	No
New Hampshire	No	No
New Jersey	Pending	No
New Mexico	Yes	Yes
New York	No	No
North Carolina	Yes	Yes
North Dakota	Yes	Yes
Ohio	Yes	Yes
Oklahoma	Yes	Yes
Oregon	No	No
Pennsylvania	Yes	Yes
Rhode Island	No	No
South Carolina	Yes	Yes
South Dakota	Yes	Yes
Tennessee	Yes	Yes
Texas	Yes	Yes
Utah	No	No
Vermont	No	No
Virginia	Yes	Yes
Washington	No	No
West Virginia	No	No
Wisconsin	No	No
Wyoming	Yes	Yes

Terrestrial plant toxicity information for isoxaflutole and its degradates

Isoxaflutole is a pigment inhibitor (*i.e.*, 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD) inhibitor) whose mode of action prevents the biosynthesis of carotenoid pigments that protect chlorophyll from decomposition by sunlight. Without carotenoid pigments, chlorophyll pigments are photo-oxidized and chloroplasts break down. Without the energy collecting action of the chlorophyll, the whole plant eventually dies. At sublethal levels, isoxaflutole exposure results in decreases in height and weight of plants. Available effects data indicate that dicot species are more sensitive compared to grasses.

Approximately 40 submissions containing terrestrial plant toxicity data have been made by the technical registrant of isoxaflutole. Those submissions include standard seedling emergence and vegetative vigor toxicity studies involving technical grade active ingredient (TGAI) isoxaflutole, formulated isoxaflutole (Balance WDG, a product that is no longer registered, and Balance Flexx, a product containing a safener), the diketonitrile degradate 202248 and the benzoic acid degradate 203328. Several submissions also included the results of field studies examining the effects of spray drift transport of isoxaflutole on non-target crops as well as effects of applying irrigation water containing isoxaflutole or its toxic degradate (*i.e.,* 202248) to crops. No additional relevant information was found in the publicly available ECOTOX database[1].

This section includes a discussion of the available plant toxicity data for isoxaflutole. Because the current action involves Balance Pro (registration 264-600), this effects characterization focuses on toxicity data from studies involving the formulated product Balance (registration number 264-567). While the Balance product contains a higher concentration of active ingredient than the Balance Pro product (75% versus 40.5%), it contains neither a safener nor another herbicidal active ingredient and is considered most comparable to the current product. As discussed below, this assessment includes a comparison of endpoints from studies involving Balance and TGAI. For vegetative vigor data, toxicity data for both Balance and TGAI exposures are used. Toxicity data for isoxaflutole's degradates is also discussed. Studies involving products that contain a safener were excluded, since these formulations are not representative of Balance Pro. Invalid studies were also excluded from consideration. **Attachment 1** includes a bibliography of registrant-submitted terrestrial plant toxicity studies. This attachment indicates which studies were excluded from this characterization, along with the rational for exclusion.

Greenhouse studies

Vegetative vigor studies with isoxaflutole

Toxicity data for both TGAI isoxaflutole and Balance is available for 10 different test species. **Table 2** and **Figure 1** include a comparison of available 25% Effect Concentrations (EC_{25}) values from vegetative vigor studies. Most often, the TGAI endpoint is the most sensitive (the only exception is cucumber shoot weight endpoint). The majority of the TGAI and Balance endpoints are within a factor of 5, with a median difference of a factor of 3.7. This is well within

[1] The publicly available ECOTOX database only contains data from registrant submitted studies.

the variability expected for terrestrial plants. Comparison of species sensitivity distributions (SSDs) derived for Balance and TGAI show no apparent difference in effects to vegetative vigor (**Attachment 2**). Based on this information, the data for both TGAI and Balance exposures are used in this analysis.

Table 2. Comparison of vegetative vigor EC_{25} values (lb a.i./A) for TGAI isoxaflutole and Balance.

Crop	Shoot length			Shoot weight		
	TGAI* EC_{25}	Balance** EC_{25}	Factor difference	TGAI* EC_{25}	Balance** EC_{25}	Factor difference
Cabbage	0.0012	0.0087 0.021	7.3 18	0.00011	0.0012 0.00288	11 26
Corn	>0.16	>0.20	NA	0.036	0.1	2.8
Cucumber	0.018	>0.016	NA	0.0077	0.0026	3.0
Lettuce	0.00021 0.000343 0.00068	0.0019	9 5.5 2.8	0.00011 0.00013 0.000914	0.0003	2.7 2.3 3.0
Oat	0.012	>0.18	NA	0.0017	0.0088	5.2
Onion	0.010	0.018	1.8	0.0023	0.0038	1.7
Ryegrass	0.014 0.0332	>0.18	NA	0.0038 0.0053	0.11	29 21
Soybean	0.026	0.03 0.052	1.2 2	0.0016	0.00222 0.0068	1.4 4.3
Tomato	0.0043	0.0084	2.0	0.0008	0.0016	2
Turnip	0.00069 0.0014 0.0034	0.143	210 100 42	0.00073 0.000822 0.0029	0.00301 0.0037	4.1 5.1 3.7 4.5 1.0 1.3

*MRIDs 43573242, 44399905 and 44896905
**MRIDs 44896904, 44906501 and 45658802
NA = not applicable because of non-definitive endpoint

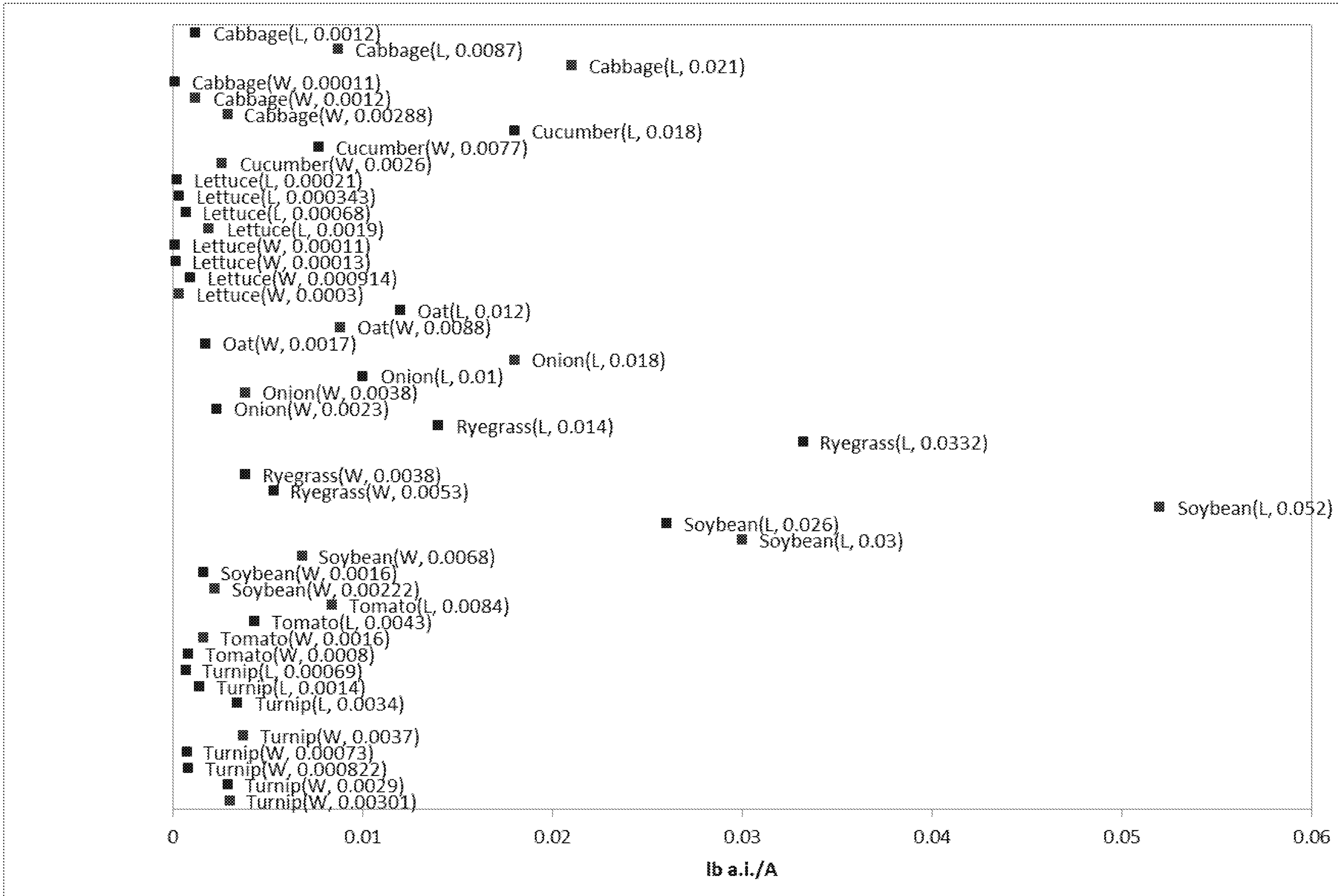


Figure 1. Vegetative vigor EC_{25} values for plants exposed to TGAI isoxaflutole (blue points) or Balance (red points). In parentheses: L = length/height of shoots, W = dry weight of shoots.

Table 3 includes the EC_{25} (25% Effect Concentration), No Observable Effect Concentration (NOEC[2]) and Lowest Observable Effect Concentration (LOEC) values available for vegetative vigor studies involving TGAI isoxaflutole and Balance. In total, toxicity data are available for 17 different species. The most sensitive EC_{25} value is 0.0000115 lb a.i./A, based on decreased shoot length in navy beans exposed to Balance (MRID 45658802). EC_{25} values for three species (navy bean, cabbage and lettuce) are <0.0001 lb a.i./A, which is <0.1% of the proposed application rate for this action. The lowest LOEC value is 0.000035 lb a.i./A for lettuce, with a corresponding NOEC of 0.00001.

Table 3. Vegetative vigor endpoints for isoxaflutole. Endpoints in lb a.i./A.

Dicot/ Monocot	Crop	Test material	Measurement	NOEC	LOEC	EC_{25}	Reference (MRID)
Dicot	Navy Bean	Balance	shoot length	0.00017	0.00052	0.0000115	45658802
Dicot	Cabbage	TGAI	root weight	0.00012	0.0004	0.000042	43573242
Dicot	Navy Bean	Balance	shoot weight	0.00017	0.00052	0.00006	45658802
Dicot	Lettuce	TGAI	root weight	0.00001	0.000035	0.000070	44399905
Dicot	Turnip	TGAI	root weight	0.00012	0.0004	0.000085	43573242
Dicot	Cabbage	TGAI	shoot weight	0.00012	0.0004	0.000110	43573242
Dicot	Lettuce	TGAI	shoot weight	0.00012	0.0004	0.000110	43573242
Dicot	Lettuce	TGAI	root weight	0.00012	0.0004	0.000120	43573242
Dicot	Lettuce	TGAI	shoot weight	0.00014	0.00054	0.00013	44896905
Dicot	Beet	Balance	shoot weight	0.000067	0.00017	0.000155	45658802
Dicot	Cotton	Balance	shoot weight	0.0000011*	0.00017	0.000197	45658802
Dicot	Lettuce	TGAI	shoot length	0.00012	0.0004	0.000210	43573242
Dicot	Lettuce	TGAI	root weight	0.000011	0.000035	0.00026	44896905
Dicot	Lettuce	Balance	shoot weight	0.00009	0.00027	0.0003	44906501
Dicot	Lettuce	TGAI	shoot length	0.00001	0.000035	0.000343	44399905
Dicot	Sunflower	Balance	shoot weight	0.00017	0.00052	0.000367	45658802
Dicot	Turnip	TGAI	root weight	0.00010	0.00054	0.000460	44399905
Dicot	Lettuce	TGAI	shoot length	0.000011	0.000035	0.00068	44896905
Dicot	Tomato	TGAI	root weight	0.00048	0.00086	0.000690	43573242
Dicot	Turnip	TGAI	root weight	0.0022	0.0076	0.00069	44896905
Dicot	Turnip	TGAI	shoot length	0.0076	0.014	0.00069	44896905
Dicot	Turnip	TGAI	shoot weight	0.00130	0.0047	0.000730	43573242
Dicot	Tomato	TGAI	shoot weight	0.00086	0.0018	0.000800	43573242
Dicot	Turnip	TGAI	shoot weight	0.00054	0.0022	0.000822	44399905
Dicot	Lettuce	TGAI	shoot weight	0.00054	0.0022	0.000914	44399905
Dicot	Cabbage	TGAI	shoot length	0.00040	0.0013	0.001200	43573242
Dicot	Cabbage	Balance	shoot weight	0.00036	0.0011	0.0012	44906501
Dicot	Turnip	TGAI	shoot length	0.000035	0.00014	0.001400	44399905

[2] For several tests, NOEC values are above the EC_{25}. In that case, the EC_{05} (5% Effect Concentration) is displayed in place of the NOEC.

Dicot/ Monocot	Crop	Test material	Measurement	NOEC	LOEC	EC_{25}	Reference (MRID)
Dicot	Soybean	TGAI	shoot weight	0.00130	0.0047	0.001600	43573242
Dicot	Tomato	Balance	shoot weight	0.0006	0.0018	0.0016	44906501
Monocot	Ryegrass	TGAI	root weight	0.00350	0.0064	0.001600	43573242
Monocot	Oat	TGAI	shoot weight	0.00048	0.0014	0.001700	43573242
Monocot	Oat	TGAI	root weight	0.00140	0.0048	0.001800	43573242
Dicot	Lettuce	Balance	shoot length	0.00027	0.00081	0.0019	44906501
Monocot	Onion	TGAI	root weight	0.00130	0.0047	0.002200	43573242
Dicot	Soybean	Balance	shoot weight	0.000106*	0.00155	0.00222	45658802
Monocot	Onion	TGAI	shoot weight	0.00470	0.016	0.002300	43573242
Dicot	Cucumber	Balance	shoot weight	0.0018	0.0054	0.0026	44906501
Dicot	Beet	Balance	shoot length	0.00017	0.00052	0.0028	45658802
Dicot	Cabbage	Balance	shoot weight	0.00155	0.00467	0.00288	45658802
Dicot	Turnip	TGAI	shoot weight	0.0022	0.0076	0.0029	44896905
Dicot	Turnip	Balance	shoot weight	0.00155	0.00467	0.00301	45658802
Dicot	Alfalfa	Balance	shoot weight	0.00155	0.00467	0.0032	45658802
Dicot	Turnip	TGAI	shoot length	0.00040	0.0013	0.003400	43573242
Dicot	Radish	Balance	shoot weight	0.0000454*	0.00052	0.00367	45658802
Dicot	Turnip	Balance	shoot weight	0.0027	0.0081	0.0037	44906501
Monocot	Onion	Balance	shoot weight	0.0018	0.0054	0.0038	44906501
Monocot	Ryegrass	TGAI	shoot weight	0.00350	0.0064	0.003800	43573242
Dicot	Sunflower	Balance	shoot length	0.00155	0.00467	0.00408	45658802
Dicot	Tomato	TGAI	shoot length	0.00350	0.0064	0.004300	43573242
Dicot	Cucumber	TGAI	root weight	0.05300	0.18	0.004600	43573242
Monocot	Ryegrass	TGAI	shoot weight	0.014	0.026	0.0053	44896905
Dicot	Canola	Balance	shoot weight	0.00467	0.014	0.00576	45658802
Monocot	Ryegrass	TGAI	root weight	0.0076	0.014	0.0059	44896905
Dicot	Soybean	TGAI	root weight	0.00470	0.016	0.006300	43573242
Dicot	Soybean	Balance	shoot weight	0.0007	0.0021	0.0068	44906501
Dicot	Cucumber	TGAI	shoot weight	0.00470	0.016	0.007700	43573242
Dicot	Tomato	Balance	shoot length	0.0018	0.0054	0.0084	44906501
Dicot	Cabbage	Balance	shoot length	0.00036	0.0011	0.0087	44906501
Monocot	Oat	Balance	shoot weight	0.0025	0.0076	0.0088	44896904
Monocot	Ryegrass	TGAI	root weight	0.00420	0.0076	0.009500	44399905
Monocot	Onion	TGAI	shoot length	0.00470	0.016	0.010000	43573242
Monocot	Oat	TGAI	shoot length	0.00140	0.0048	0.012000	43573242
Dicot	Alfalfa	Balance	shoot length	0.00052	0.00155	0.0136	45658802
Monocot	Ryegrass	TGAI	shoot length	0.00350	0.0064	0.014000	43573242
Dicot	Cucumber	TGAI	shoot length	0.00470	0.016	0.018000	43573242
Monocot	Onion	Balance	shoot length	0.0054	0.016	0.018	44906501
Dicot	Cabbage	Balance	shoot length	0.00155	0.00467	0.021	45658802

Dicot/ Monocot	Crop	Test material	Measurement	NOEC	LOEC	EC_{25}	Reference (MRID)
Dicot	Radish	Balance	shoot length	0.00467	0.014	0.026	45658802
Dicot	Soybean	TGAI	shoot length	0.00470	0.016	0.026000	43573242
Dicot	Soybean	Balance	shoot length	0.000704*	0.00155	0.03	45658802
Monocot	Ryegrass	TGAI	shoot length	0.00095	0.0022	0.033200	44399905
Monocot	Corn	TGAI	shoot weight	0.07900	0.16	0.036000	43573242
Dicot	Cotton	Balance	shoot length	0.00052	0.00155	0.0425	45658802
Dicot	Soybean	Balance	shoot length	0.0063	0.019	0.052	44906501
Dicot	Canola	Balance	shoot length	0.00467	0.014	0.0748	45658802
Monocot	Corn	Balance	shoot weight	0.024	0.049	0.1	44896904
Monocot	Ryegrass	Balance	shoot weight	0.055	0.097	0.11	44896904
Monocot	Corn	TGAI	root weight	0.16000	NA	0.120000	43573242
Dicot	Turnip	Balance	shoot length	0.0138	0.04315	0.143	45658802
Dicot	Turnip	Balance	shoot length	0.0081	NA	>0.0081	44906501
Dicot	Cucumber	Balance	shoot length	0.016	NA	>0.016	44906501
Monocot	Ryegrass	TGAI	shoot length	0.0043	0.0076	>0.026	44896905
Monocot	Corn	TGAI	shoot length	0.07900	0.16	>0.16	43573242
Monocot	Oat	Balance	shoot length	NA	0.0025	>0.18	44896904
Monocot	Ryegrass	Balance	shoot length	0.18	NA	>0.18	44896904
Monocot	Corn	Balance	shoot length	0.02	0.049	>0.20	44896904
Monocot	Ryegrass	TGAI	shoot weight	0.02600	NA	NA	44399905

*EC_{05}
NA = not available

Seedling emergence studies with isoxaflutole

Table 4 includes the EC_{25}, NOEC (or EC_{05}) and LOEC values available for seedling emergence studies involving TGAI isoxaflutole and Balance. Toxicity data are available for 10 different species. All endpoints are based on shoot length, as weight was not quantified in the available studies. The most sensitive endpoints for the dicots are EC_{25} and NOECs of 0.00047 and 0.00011 lb a.i./A, respectively, based on decreased shoot length in turnip exposed to TGAI (MRID 43573242). For monocots, the most sensitive endpoints are for onion, with EC_{25} of 0.016 and a NOEC of 0.012 lb a.i./A. A comparison of a SSD generated using TGAI data to a SSD generated using Balance indicated that there is difference in effects to SE attributed to Balance and TGAI (**Attachment 2**).

Table 4. Seedling emergence endpoints for isoxaflutole. Endpoints in lb a.i./A.

Dicot/ Monocot	Crop	Test material	Measurement	NOEC	LOEC	EC_{25}	Reference (MRID)
Dicot	Turnip	TGAI	shoot length	0.00011	0.00027	0.000470	43573242
Dicot	Lettuce	TGAI	shoot length	0.00049	0.001	0.000660	43573242
Dicot	Cabbage	TGAI	shoot length	0.00110	0.0029	0.001490	43573242
Dicot	Cabbage	Balance	shoot length	0.0007	0.003	0.003	44839702
Dicot	Lettuce	Balance	shoot length	0.0018	0.0054	0.0039	44896902
Dicot	Cucumber	TGAI	shoot length	NA	0.002	0.004540	43573242
Dicot	Tomato	TGAI	shoot length	0.00380	0.0068	0.005700	43573242
Dicot	Cucumber	Balance	shoot length	0.0002*	NA	0.0067	44839702
Dicot	Turnip	Balance	shoot length	0.0015*	NA	0.0077	44839702
Monocot	Onion	TGAI	shoot length	0.01200	0.023	0.015760	43573242
Dicot	Soybean	TGAI	shoot length	0.00710	0.012	0.018570	43573242
Dicot	Tomato	Balance	shoot length	0.006*	NA	0.019	44839702
Monocot	Oat	TGAI	shoot length	0.00710	0.012	0.021090	43573242
Monocot	Ryegrass	Balance	shoot length	0.0022	0.0069	0.024	44839702
Monocot	Oat	Balance	shoot length	0.01*	NA	0.035	44839702
Monocot	Onion	Balance	shoot length	0.0022	0.0069	0.05	44839702
Monocot	Corn	Balance	shoot length	0.012	0.024	0.059	44839702
Monocot	Ryegrass	TGAI	shoot length	0.02100	0.043	0.079670	43573242
Dicot	Soybean	Balance	shoot length	0.05	0.2	0.12	44839702
Monocot	Corn	TGAI	shoot length	0.04500	0.092	>0.19	43573242

*EC_{05}
NA = not available

Toxicity of Degradates

Isoxaflutole degrades into two compounds, a diketonitrile degradate, α-(-(cyclopropylcarbonyl)-2-(methylsulfonyl)-β-oxo-4-(trifluromethyl)benzenepropanenitrile), also known as RPA 202248, and a benzoic acid degradate, 2-methylsulfonyl-4-trifluoromethylbenzoic acid, also known as RPA 203328 (**Figure 2**). Available data indicate that the RPA 202248 metabolite has herbicidal activity; however, RPA 203328 does not appear to impact terrestrial plants.

Only a limited number of data are available for RPA 202248. Vegetative vigor data are available for cabbage, lettuce and turnip. The utility of both studies is limited because they only included three test rates, and EC_{25} values were not quantified for several endpoints. The EC_{25} for effects to shoot length of turnip was 0.00018 lb a.i./A (MRID 45535401), which is more sensitive compared to the data available for isoxaflutole (EC_{25} values range 0.00069-0.143 lb a.i./A). EC_{25} values based on decreases of whole plant weight are 0.00013, 0.00018 and 0.00016 lb a.i./A for cabbage, lettuce and turnip, respectively (MRID 45535405). No seedling emergence toxicity data are available for degradate RPA 202248.

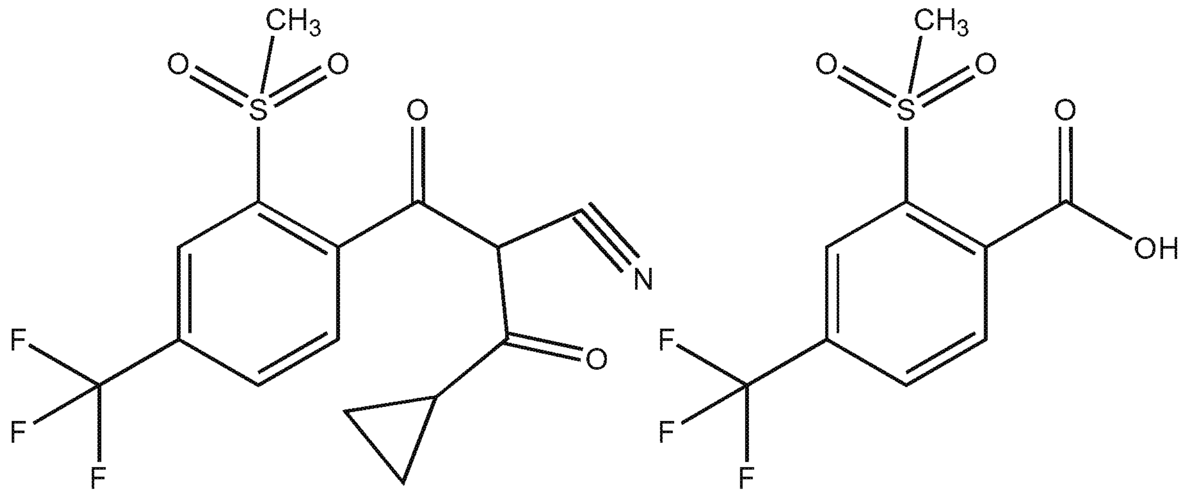


Figure 2 Structures of the primary degradates of isoxaflutole, RPA 202248 (left) and RPA 203328 (right).

Tier I seedling emergence and vegetative vigor data are available for 10 species exposed to degradate RPA 203328 (cabbage, corn, cucumber, lettuce, oat, onion, ryegrass, soybean, tomato and turnip; MRIDs 44399906 and 44399907). In both studies, <25% effects were observed to all test species exposed to 0.14 lb a.i./A of this degradate. This indicates that degradate RPA 203328 is orders of magnitude less toxic to plants, compared to isoxaflutole.

Field studies

Simulated drift exposure

Field studies were conducted on four dicot species (canola, cotton, soybean and sunflower) and two monocot species (oats and rice) exposed to applications of Balance at 0.0014 lb a.i./A (MRIDs 45244504-45244509). These studies were conducted with the intention of evaluating potential effects at rates that are representative of spray drift deposition.

Applications were made either before planting, at planting or after planting. Plants were evaluated for changes in height and seed yield as well as phytotoxicity. For cotton, a slight decrease in height was observed, along with a 22% reduction in seed yield. No other test species had significant impacts to yield or height. Phytotoxicity was observed for cotton, oats and soybeans. No significant effects were observed for sunflower or rice.

There are several notable limitations associated with the submitted field studies. First, all of the submitted studies are of limited utility because their study designs did not comply with EFED's recommendations on submitted protocols. In addition, replicate information was not submitted for height and phytotoxicity; therefore, reported results could not be verified by EFED reviewers.

Finally, field data were not submitted for the most sensitive species tested in the greenhouse studies (*i.e.,* cabbage, lettuce, navy beans and turnip).

Simulated irrigation exposure

Studies are available with dicot species exposed to isoxaflutole's phytotoxic degradate (RPA 202248) that are intended to simulate exposure of crops via contaminated irrigation. In a study with cabbage, lettuce, sugar beet and turnip, crops were irrigated multiple times with contaminated water containing ≤3.2 ppb of RPA 202248. Note that original risk assessment supporting the EUP for isoxaflutole on soybeans (D370959) found that irrigation from surface water sources had one-in ten year peak concentrations of 3.030 ppb of RPA 202248 and the most recent assessment of the concentrations of total toxic residues (isoxaflutole plus RPA 202248) had concentrations as high as 2.95 ppb based on a pre-plant application on corn in Wisconsin (D417786). Reduced weight was observed in cabbage (7.9%) and lettuce (13%), but not in turnip or sugar beet (MRID 45244510). In a study involving cotton exposed to 4 ppb through two irrigation events, a reduction in seed yield (18%) was observed (MRID 45244501).

Incident Reports

Overview of Incidents

The Ecological Incident Information System (EIIS, version 2.1.1 (1)) and Aggregate Incident Reports (version 1.0) databases were reviewed on February 25 and March 18, 2015, respectively, for ecological incidents involving isoxaflutole. The results of this review are discussed below. A summary table for incidents attributed to non-direct plant treatment (*e.g.,* crossover or drift) is found in **Attachment 3**.

Of the 508 isoxaflutole incidents reported in the EIIS database between 1999 and present (**Table 5**), the majority (n = 466; 92%) were corn and field corn damage from direct application. In regards to the legality of use, 449 were from registered uses, 23 from misuse and 36 were undetermined (**Table 6**). Due to so many corn damage incidents being from direct application, most of the incidents (83%) had a certainty index (**Table 7**) of probable or highly probable. Another 17% had a certainty index of possible and only 1 had an index of unlikely.

Of the 8338 incidents reported in the Aggregate database between 1999 and present, 8320 of these (99.8%) were domestic plant incidents (**Table 8**).

It should be noted that a lack of reported incidents does not imply that no incidents occurred. Also, in many cases not involving direct plant treatment, information in the reports was not clearly documented or isoxaflutole was reportedly applied in combination with or in the presence of another pesticide. In the latter case, it was not possible to determine which pesticide caused the incident. This is especially true of incidents of undetermined legality that also involved atrazine and of the only reported animal incident, a bee incident that also involved chlorpyriphos.

Table 5. Summary of incidents reported in the EIIS Database from use of isoxaflutole from 1999 through present.

Type of Incident/Species Affected	EIIS Database[1]		
	Number of Incidents	Incidents Associated with Balance	
		Number	Percent
Non-Plant:			
Honeybee (*Apis* sp.)	1[2]	--[3]	--
Plant:			
Alfalfa (*Medicago sativa*)	1	0	0
Corn (*Zea mays*)	328	312	95
Field Corn	175	138	79
Soybean (*Glycine max*)	2	0	0
Lentil (*Lens culinaris*)	1	0	0
Total Incidents	508	450	89

[1] Queried February 25, 2015.
[2] This incident (I027366-001, reported on August 5, 2014) was from a beekeeper in ND and also involved chlorpyriphos.
[3] – Information or parameter not reported by database.

Table 6. Summary of incident numbers by legality and certainty from EIIS Database.[1]

Legality	Certainty				Category Totals
	Highly Probable	Probable	Possible	Unlikely	
Registered Use	0	403	45	1	449
Misuse	0	2	1	0	3
Accidental Misuse	2	14	0	0	16
Intentional Misuse	0	0	4	0	4
Undetermined	0	0	36	0	36
Totals	2	419	86	1	508

[1] Queried February 25, 2015 (1999-present).

Table 7. The certainty index in EIIS was based on the following.

Certainty Index	Criteria
Highly probable	Pesticide was confirmed as the cause through residue analysis or other reliable evidence, or the circumstances of the incident along with knowledge of the pesticide's toxicity or history of previous incidents give strong support that this pesticide was the cause.
Probable	Circumstances of the incident and properties of the pesticide indicate that this pesticide was the cause, but confirming evidence is lacking.
Possible	The pesticide possibly could have caused the incident, but there are possible explanations that are at least as plausible. Often used when organisms were exposed to more than one pesticide.
Unlikely	Evidence exists that a stressor other than exposure to this pesticide caused the incident, but that evidence is not conclusive.
Unrelated	Conclusive evidence exists that a stressor other than exposure to the given pesticide caused the incident.

Table 8. Detail showing portion of non-human incidents by year associated with Balance, according to the Aggregate Database.[1]

Exposure Severity Code	Description	Number of Incidents	Incidents Associated with Balance	
			Number	Percent
Total Inc.	Total Number of Reported Incidents	8339	7467	90
DA	Domestic Animal - Fatality	0	0	--
DB	Domestic Animal - Major	0	0	--
DC	Domestic Animal - Moderate	1	0	0
DCDE	Domestic Animal - Moderate, Minor and Unknown	0	0	--
DD	Domestic Animal - Minor	0	0	--
DE	Domestic Animal - Unspecified	0	0	--
DWB	Drinking Water - Moderate	0	0	--
DWC	Drinking Water - Minor	0	0	--
GB	Groundwater - Moderate (with possibly mixed types of water)	0	0	--
GC	Groundwater - Minor (with possibly mixed types of water)	2	2	100
GWB	Groundwater - Moderate	0	0	--
GWC	Groundwater - Minor	0	0	--
ONT	Other Nontarget	0	0	--
PB	Plant Damage - Minor	8336	7465	90
PDB	Property Damage - Moderate	0	0	--
PDC	Property Damage - Minor	0	0	--
SWB	Surface Water - Moderate	0	0	--
SWC	Surface Water - Minor	0	0	--
WB	Wildlife - Minor	0	0	--

[1] Queried March 18, 2015 (1999-present).

Of the 508 isoxaflutole incidents reported in the EIIS database (**Table 5**) and the 8338 reported in the Aggregate database (**Table 8**), 95 and 79%, respectively, were from application of Balance products. From 1999-2005, the majority of isoxaflutole incident reports were associated with applications of Balance (**Table 9; Figure 3 and Figure 4**); however, after that time, the majority of the reported incidents were associated with other formulated products containing isoxaflutole.

Table 9. Detail showing portion of incidents by year associated with Balance, according to EIIS Database.

Year Damage Occurred	EIIS Database[1]		
	Number of Incidents	Incidents Associated with Balance	
		Number	Percent
1999	51	51	100
2000	178	178	100
2001	90	90	100
2002	76	76	100
2003	24	23	100
2004	24	21	88
2005	17	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0
2010	11	6	55
2011	18	4	24
2012	16	1	6
2013	2	0	0
2014	0	0	0
2015	1	0	0
Total	508	450	58

[1] Queried February 25, 2015 (1999-present).

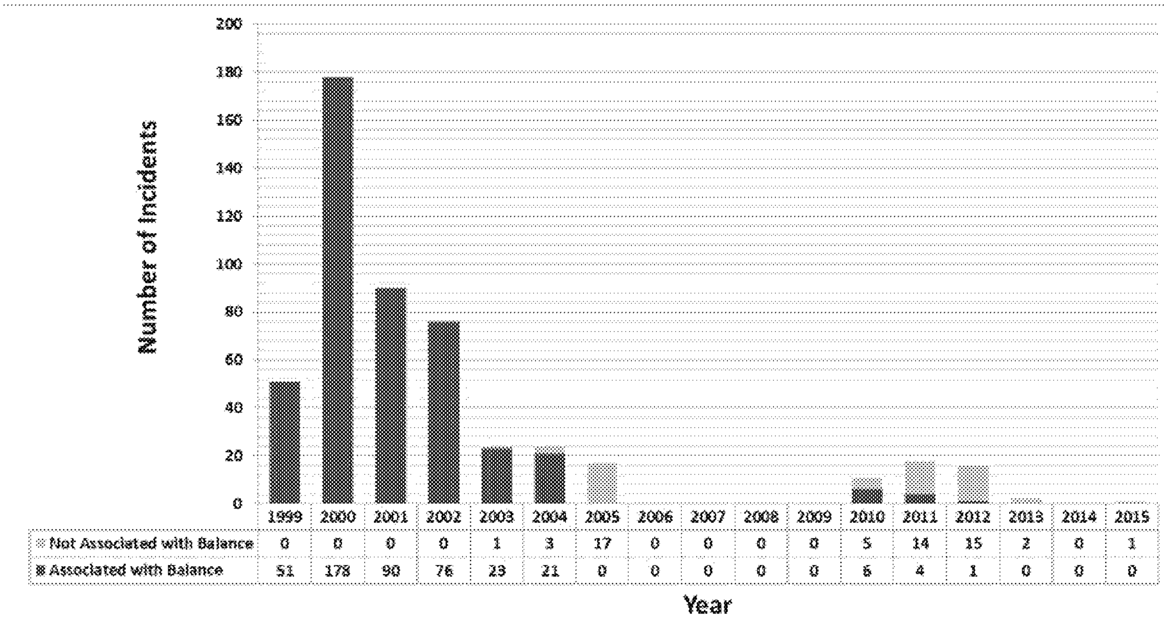
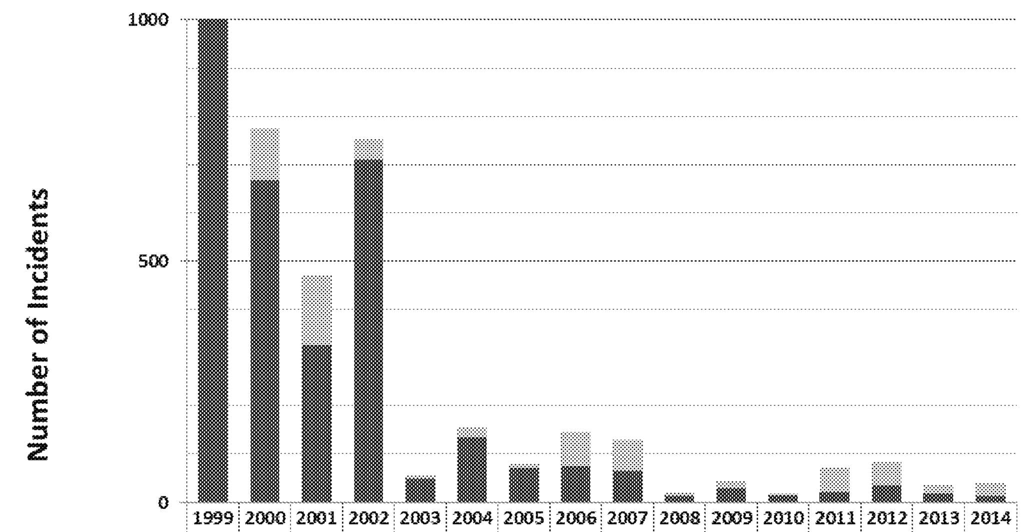


Figure 3. Comparative number of incidents of plant damage per year associated with Balance and other products containing isoxaflutole, according to EIIS Database (queried Feb. 25, 2015, showing 1999 through present).



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Not Associated With Balance	240	107	145	42	9	19	8	69	64	7	14	4	50	52	16	25
Associated with Balance	5219	668	327	711	49	136	71	76	65	13	29	14	21	34	19	13

Year

Figure 4. Comparative number of incidents of plant damage per year associated with Balance and other isoxaflutole products, according to Aggregate Database (queried March 18, 2015, showing 1999 through present).

Details of Incidents from EIIS Database

Further analysis of the incidents reported in the EIIS database was done to better pinpoint the exposure scenarios associated with reported damage to crops (**Table 10- Table 12**). Since corn was the only registered use at the time of the reported incidents, most of the reported damage was to corn and field corn from direct plant treatment (**Table 10**) and those incidents had a certainty index of probable. The only incidents rated highly probable were from misuse rather than registered use and are discussed later (see **Table 12**). All reported damage to other crops with a certainty index of probable were from carryover, where corn was treated in the field earlier – this included 25 incidents of damage to alfalfa, dry beans, lentils, soybeans and sugar beets. These incidents are summarized in **Attachment 3** and discussed below. Incidents attributed to registered use and with a certainty index of possible or lower included 3 carryover incidents (**Table 11**). These incidents are summarized in **Attachment 3** and discussed below.

Incidents attributed to misuse or undetermined legality included 2 spray drift incidents, 1 compost incident and 2 incidents that did not include enough information for further characterization (**Table 12**). The distances involved in the spray drift incidents were not quantitated; 1 specified that it was in the vicinity of the isoxaflutole application and the other 2 did not report a distance. These incidents are summarized in **Attachment 3** and discussed below.

Table 10. Incidents from EIIS Database (queried Feb. 25, 2015) showing only those attributed to registered use on corn with certainty rating of probable or higher.[1]

Associated Route of Exposure	Number of Incidents by Crop						
	Corn[2]	Field Corn[2]	Alfalfa	Dry Bean[3]	Lentil	Soybean	Sugar beet
Direct plant treatment	332: 4 Banded 1 Band, inc. 84 Broadcast 209 Pre-broad. 2 Pre-plant 32 Unknown	43: 29 Broadcast 3 Pre-plant 11 Unknown	0	0	0	0	0
Carryover (crop planted on field treated in previous season)	0	0	1 (pre-broad)	7 (pre-broad)	1 (pre-broad)	2 (pre-broad)	14 (pre-broad)
Spray drift transport	0	0	0	0	0	0	0
Contaminated irrigation water	0	1(drinking)	0	0	0	0	0
Runoff	1 (broadcast and soil transport)	0	0	0	0	0	0
Others/Compost	1 Pre-broad.	0	0	0	0	0	0

[1]There were no incidents attributed to Registered Use with a certainty rating of Highly Probable.
[2]Corn is the only registered crop.
[3] Dry bean is *Phaseolus* sp. (I010563-41, -42, -43, -45, -46, -47) – could be common bean or others.

Table 11. Incidents from EIIS Database (queried Feb. 25, 2015) showing only those attributed to registered use on corn with certainty rating of possible or lower.[1]

Associated Route of Exposure	Number of Incidents by Crop		
	Corn[2]	Field Corn[2]	Alfalfa
Direct plant treatment	11	31	0
Carryover (crop planted on field treated in previous season)	0	1	2 (both on site)
Spray drift transport	0	0	0
Contaminated irrigation water	0	0	0
Runoff	0	0	0
Others/Compost	1	0	0

[1]All incidents except one had a rating of possible; one direct corn treatment incident was rated as unlikely due to the type of damage.
[2]Corn is the only registered crop.

Table 12. Incidents from EIIS Database (queried Feb. 25, 2015) showing only those attributed to misuse or to undetermined legality.[1]

Associated Route of Exposure	Number of Incidents by Crop (distance for incidents from non-direct application)			
	Corn[2]	Field Corn[2]	Alfalfa	Fruit Tree
Direct plant treatment	28[3]	24[4]	1[5]	0
Carryover (crop planted on field treated in previous season)	0	0	0	0
Spray drift transport	1(in vicinity)[6]	0	0	1(distance not reported)[5]
Contaminated irrigation water	0	0	0	0
Runoff	0	0	0	0
Others/Compost	3 (1 was compost on site, 2 distance and route not reported)[7]	1[8]	0	0

[1]Of the 59 total incidents, 23 were attributed to misuse and 36 were undetermined. Certainty: 2 incidents were highly probable, 16 were probable and 41 were possible.
[2]Corn is the only registered crop.
[3] Of these 28 incidents 16 were of undetermined legality with certainty of possible and 12 attributed to misuse with 10 probable and 2 possible.
[4] Of these 24 incidents 17 were of undetermined legality with certainty of possible and 7 attributed to misuse with 1 highly probable, 1 possible and 5 probable.
[5]Incident attributed to misuse and certainty was possible.
[6]Incident attributed to misuse and certainty was highly probable.
[7]All three incidents also involved atrazine; all were undetermined legality and possible certainty.
[8]May have been direct application but unclear; attributed to misuse and certainty was probable.

Description of Incidents Attributed Non-Direct Plant Treatment Exposure Routes

Details of all incidents that were not from direct plant treatment were examined further. Special attention was given to try and identify circumstances contributing to carryover damage to crops planted after application to corn and distances involved in spray drift or runoff incidents. Other exposure routes, such as compost transport, were also examined. A summary table for these incidents is found **Attachment 3** and a summarized description of the information found below.

Incidents Attributed to Carryover

All of the 28 carryover incidents in the EIIS database involved the registered use of isoxaflutole on corn the year before and subsequent damage to crops grown on the site – with the exception that two did not clearly state that the application had been made the previous year (I010563-046 merely stated previous treatment and I016407-052 was unclear whether the isoxaflutole application in question had been from a current or previous application or whether the carryover designation was for another chemical). Of the 28 carryover incidents, 25 occurred in 2000 from application in 1999 and the product used in all cases was Balance WDG. Though information wasn't always available, the magnitude varied from 15 to 120 acres and application rate from 1.0 to 1.5 oz/acre of Balance WGD. In 2003, 2 incidents were reported, both involving 160 acres of alfalfa, one identified the product, Epic (Flufenacet + Isoxaflutole, I014426-009), and the other did not identify a product (I014426-005). An incident in 2005 (I016407-052) was possibly caused by application of Balance Pro – though it was unclear whether this meant by carryover or direct treatment because the registrant attributed the cause, rather, to carryover of another pesticide (FirstRate, with cloransulam as the active ingredient). Crops that were damaged by carryover included alfalfa, dry beans, lentils, soybeans and sugar beets.

Three incidents involved damage to alfalfa: in 2000, in Powell, WY, 32 acres were damaged (I010653-018). In 2003, in Brookings County, SD, two incidents of damage to 160 acres of alfalfa were reported (I014426-005 and I014426-009) and though they are listed as separate incidents, enough similarities exist to suggest that they might be duplicate reports of the same incident. In incident I014426-005, a farmer alleged that the registered use of isoxaflutole to his corn crop in the spring of 2002 carried over to his alfalfa crop, causing leaf loss; and in I014426-009) a farmer claimed that the registered use of isoxaflutole to his corn crop caused plant damage from carryover. In the later, the product, EPIC (Flufenacet + Isoxaflutole), was applied on corn the year before. The registrant denied the effect in both cases.

Seven incidents in 2000 involved damage to dry beans: in Edson, KS, 150 acres of a dry beans crop were damaged (I010563-041) from application of 1.5 oz/acre of Balance WDG; in Riverton, WY, all 30 acres of a dry beans crop were damaged (I010563-042); in Miles City, MT, all 15 acres of a dry beans crop were damaged (I010563-043); in Hysham, MT, a crop of dry beans of unknown acreage was damaged (I010563-045); in Worland, WY, a crop of dry beans of unknown acreage was damaged (I010563-046); in Glendive, MT, a crop of dry beans of unknown acreage was damaged (I010563-047); and in Bathgate, ND, a crop of dry beans of unknown acreage was damaged (I010653-017).

An incident in 2000 involved damage to lentils: in Riverton, WY, 1 oz/acre of Balance WDG damaged 20 acres out of 40 acres of dry beans (the species damaged was listed as lentils, but the report called them dry beans). The pesticide had been applied to a corn crop the year before but there was a carryover that damaged the beans. The database noted that part of the information for that report was taken from I010507-010.

Two incidents in 2000 involved damage to soybeans. In Waynetown, IN, the registered use of Balance WDG damaged a crop of soybeans (I010563-044). The pesticide had been applied to corn the year before, but there was enough carryover to kill the soybeans. In Sloan, IA, the registered use of Balance WDG herbicide damaged a crop of soybeans as the result of a carryover from the previous year when it was applied to corn (I010653-016).

Fourteen incidents in 2000 involved damage to sugar beets attributed to carryover from registered use of Balance WDG in 1999. In Worland, WY, two incidents were reported, one citing damage was to 100 acres of a 135 acre crop of sugar beets (I010472-038). Report stated that there was enough Balance in the soil to damage the sugar beets. The other (I010472-041) involved damaged all 16 acres of sugar beets. This incident was logged in the EIIS database as a direct treatment, rather than carryover. In Basin, WY, damage was to 70 acres of an 84 acre plot of sugar beets (I010472-042). Report stated that there was sufficient carryover in the soil to damage the sugar beets. In Riverton, WY, damage was to 10 acres of sugar beets (I010472-054).

There had been 30 acres planted, of which 10 acres were damaged. In Joliet, MT, damage was to all 46 acres of a sugar beets crop (I010472-055). In Arapahoe, WY, damage was to all 45 acres of a crop of sugar beets (I010472-068). In Worland, WY, 100 acres of a 200-acre crop of sugar beets was damaged (I010472-069). In Fairview, MT, damage was to all 110 acres of a crop of sugar beets (I010472-075). In Worland, WY damaged was to all 36 acres of a crop of sugar beets (I010472-076). In Worland, WY, damage was to all 26 acres of a crop of sugar beets (I010472-077). In Terry, MT, three incidents were reported. All three involved damage to an undetermined acreage of sugar beets (I010563-048, I010563-049 and I010563-050). One of these incidents did not specify that the isoxaflutole treatment was from the previous year but that the damage was a consequence of a previous treatment. Also, incident I010563-50 states that it is a different incident from I1010563-49. In Billings, MT, an undetermined acreage of sugar beets was damaged (I010563-051). No information was given on the application rate or the area affected.

All these incidents were attributed to carryover from registered use of Balance WGD on corn the year before (1999). No further information was available to further characterize causality.

Incidents Attributed to Spray Drift or other Exposure Routes

Two spray drift incidents were recorded in the EIIS database, both were attributed to misuse and both involved the isoxaflutole product, Corvus, although one (I027332-004) also involved a glyphosate product, making the role of isoxaflutole less clear. Damage was to corn and fruit trees. Details of the incidents follow, but no distance information was available for either.

In 2012 in Holt County, MO (I024431-045), 75% of 240 acres of corn was damaged from accidental misuse. The corn displayed the adverse effect of lodging after an application of the products Corvus (a.i. thiencarbazone-methyl and isoxaflutole) and Touchdown (a.i. glyphosate). There was alleged miscommunication between the grower and retailer as to when to spray. A settlement was reached and the registrant stated that the probable cause was late application.

In 2015, in Iowa County, IA, Corvus Herbicide (a.i. isoxaflutole) was allegedly applied during 25-30 mph winds toward a property causing concern for drift to fruit trees and bees. No adverse effects were noted at the time of the call and the legality was determined to be misuse.

Neither of the spray drift incidents provided insight into distances involved in crop damage from spray drift.

Two incidents from the EIIS database could possibly have involved runoff – one was attributed to soil transport and the other to drinking water. Neither of these incidents had sufficient information to determine distance or characteristics of the exposure. Both involved damage to corn and details, though limited, are given below.

In 2002, in Onslow, IA, Aventis allegedly damaged 48 acres of a 100-acre crop of field corn. No mention was made in the report of the type of damage inflicted (I013103-017).

Also in 2002, in Charles City, IA, application of 14 oz/acre of EPIC DF Herbicide allegedly damaged 10,000 to 20,000 field corn plants per acre (I013092-004). The total area was not mentioned and the registrant attributed the damage to cold wet weather, suggesting that the corn was not able to grow due to poor growing conditions. The route of exposure in the EIIS database was labeled as "Drinking" but it was not clear from the report whether this was due to the mention of wet weather or some other factor.

One incident involved contaminated compost, but causality was unclear since atrazine was also involved. In 2012, in Butler County, IA, 100% of 80 acres of corn exhibited stand reduction (I024202-019) after an application of the products Corvus (a.i.'s thiencarbazone-methyl and isoxaflutole) and a non-specific atrazine product. The Registrant suggested that the stand reduction may be due to a late application and/or the adjuvant contained in mix. The legality was categorized as undetermined.

Five incidents in the EIIS database did not have a reported route of exposure. Of these two were from registered use, one from misuse and two of undetermined legality. All five involved damage to corn. Of the two attributed to registered use, one (I010985-004, in 2000) was unremarkable and possibly from direct treatment, though information was not available to confirm, and the other (I024295-038, 2012) also involved a glyphosate product and so causality was unclear. The incident attributed to misuse, however (I016407-047, 2005), did contain some useful information in that the application rate exceeded the recommended rate and provided evidence that damage to corn can occur at that rate (0.11 lb a.i./acre, see write-up and calculations below). The two of undetermined legality did not provide much useful information on the contribution of isoxaflutole to causality because atrazine was also involved in both incidents.

Conclusions from Incident Reports

Several conclusions can be drawn from the incident reports for isoxaflutole from information found in the EIIS and Aggregate databases:

- almost all incidents involved damage to plants -- no clear effects to animals were seen from information found in the two databases;
- direct application to corn or field corn from the registered use was clearly shown to have the potential to cause damage to those crops;
- incidents continue to occur; however, the number of reported incidents has lessened since 2004;
- prior to 2005, Balance was associated with the majority of incidents; since then, Balance was associated with a lower proportion of the isoxaflutole incidents; and
- carryover from registered use on corn can cause damage to other crops the following year.

Though some evidence was seen for potential damage to crops from spray drift, runoff and compost spreading, the information was insufficient to determine amounts or distances involved.

Exposure Characterization

Spray Drift Transport

In this assessment, exposure to non-target plants via spray drift deposition is estimated using two different methods. The first is the Tier I AgDRIFT model. The second is based on registrant submitted field study involving Balance (MRID 49414301[3]). The data from the drift study are limited in utility to the nozzles included in that study (*i.e.,* XR, TT and AIXR). Since nozzles are not specified on the proposed label for this action, AgDRIFT is used to represent spray drift exposure for all other nozzles.

AgDRIFT

The Tier I Ground AgDRIFT model (v. 2.1.1)[4] was used to derive **Equation 1**. In this equation, the deposition rate (in lb a.i./A) is calculated for different distances (in feet) from the edge of the treated field. The value of 0.094 in this equation is based on the maximum application rate proposed for this action. This equation was used to generate **Figure 5**. The risk assessment involves comparison of these deposition estimates with the toxicity data described above.

Equation 1. $Deposition\ rate = \frac{1.0079}{(1+5.5513*distance)^{0.8523}} * 0.094$

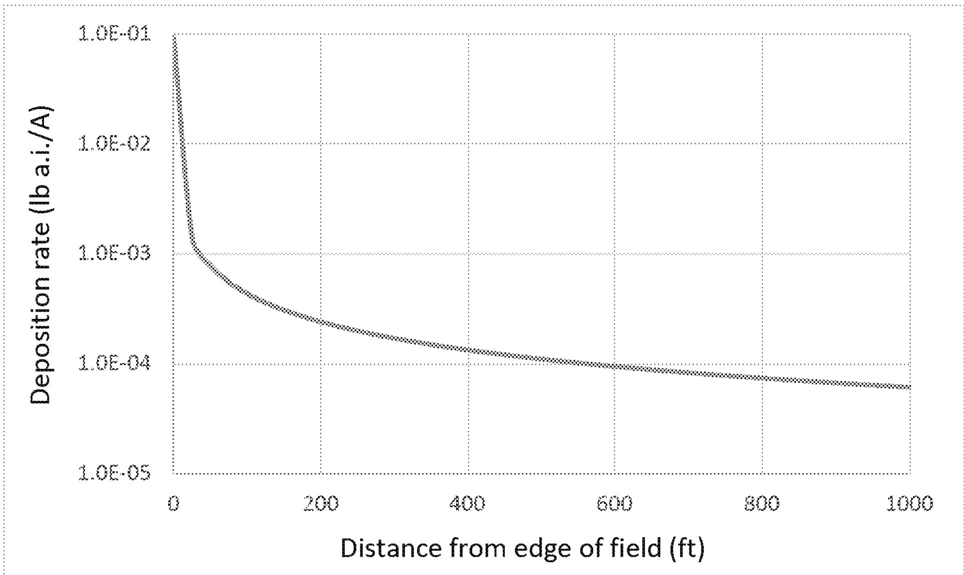


Figure 5. Spray drift deposition calculated using AgDRIFT for low boom, ASAE fine to medium/coarse.

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[3] Hanzas, J., B. Brayden, and C. Hofmann. 2014. *Spray Drift Field Deposition Testing for Isoxaflutole: Final Report.* Submitted by Bayer CropScience, Research Triangle Park, NC. Study ID: MEISN015, Study Performed by Stone Environmental. Study No. 14-043.1.

[4] http://www.epa.gov/oppefed1/models/water/

Registrant-submitted field study and wind tunnel trials

The registrant submitted a spray drift field study (guideline 840.1200; MRID 49414301) and a supporting droplet size distribution study (guideline 840.1100; MRID 49414301) to support labeling and risk assessment for isoxaflutole applied to isoxaflutole-tolerant soybeans. The test system was fallow field in York, Nebraska consisting of a bare ground field site of less than 2% slope with an area of greater than 1,000 by 1,000 feet. For each application, three 82.5 ft wide swaths approximately 600 ft long were applied. The total width of the swaths was 247.5 ft. There were five experimental trials using different nozzles and wind speeds (**Table 13**). A standard application was made using an XR nozzle which is intended to be comparable to the Spray Drift Task Force (SDTF) standard spray applications. A TT nozzle was used to generate coarse sprays and an AIXR was used for very coarse sprays. Applications were made at 20 inches (50.8 cm) which is the same as the low boom height applications in the SDTF datasets. The AIXR nozzles were used for very coarse sprays. Pressures were adjusted for each nozzle to give the desired spray quality, and the speed of the tractor and spray rig were adjusted to give the intended application rate of 0.094 lb/acre which is the maximum single application rate of isoxaflutole to soybeans.

Table 13. Wind speeds and nozzles used in different treatments included in registrant spray drift study.

Treatment	Nozzle	Wind Speed (mph)
standard	XR	12.4
coarse/low wind	TT	7.6
coarse/high wind	TT	13.0
very coarse/low wind	AIXR	6.6
very coarse/ high wind	AIXR	10.1

The data was fitted to a modified Morgan-Mercer-Floden function following a log-transform of the deposition data. The fitted equation was done so the deposition from each swath could be accounted for separately:

$$f = \sum_{i=1}^{3} \frac{B}{\left(1 + C(d + 82.5i)\right)^{D}}$$

Where d is the distance from the edge of the field, f is the fraction of the application rate at distance d, and I is the swath number. The fitted parameters are B, C, and D. B is the value of f at zero distance, C is the 'slope' parameter, and D is the curvature of the function. The constant 82.5 is the swath width. In effect, this equation accounts for the drift from each of the application swaths. The value of i was 3 for this analysis. The fitted deposition curves are shown in **Figure 6**. The 90% fine to medium/coarse low-boom ground spray deposition curve from AgDrift which is the finest 'medium' spray, which would be used to evaluate this data in the absence of field spray drift data is also included in the figure. The AgDrift curve was generated using 5 swaths of 45 feet for a total of 225 which is similar to the field study total width of 247.5 ft. The AgDrift is most similar to that for the XR high wind curve from the field study, although the XR curve shows a greater decrease in deposition at long distances. *Note that this AgDrift curve is for* *comparison to the field data and not for risk assessment. The AgDrift curve for risk assessment would use 20 swaths for a total width of 900 ft.* The high wind speed drift trials for the TT nozzle and the AIXR nozzle show greater drift than for the low wind speed trials with the same nozzle. The current Balance Pro label restricts applications to coarse spray which would be represented by the TT nozzle data. For the purposes of risk assessment, the high wind speed trial using for the AIXR nozzle was used which would be appropriate if language restricting use to very coarse nozzle applied with a boom no higher than 20 inches from the ground and wind speed restriction of 10 mph. Current language does not specify a maximum boom height but indicates to "Keep the spray boom at lowest possible spray height above the target surface." There is no wind speed restriction on the label.

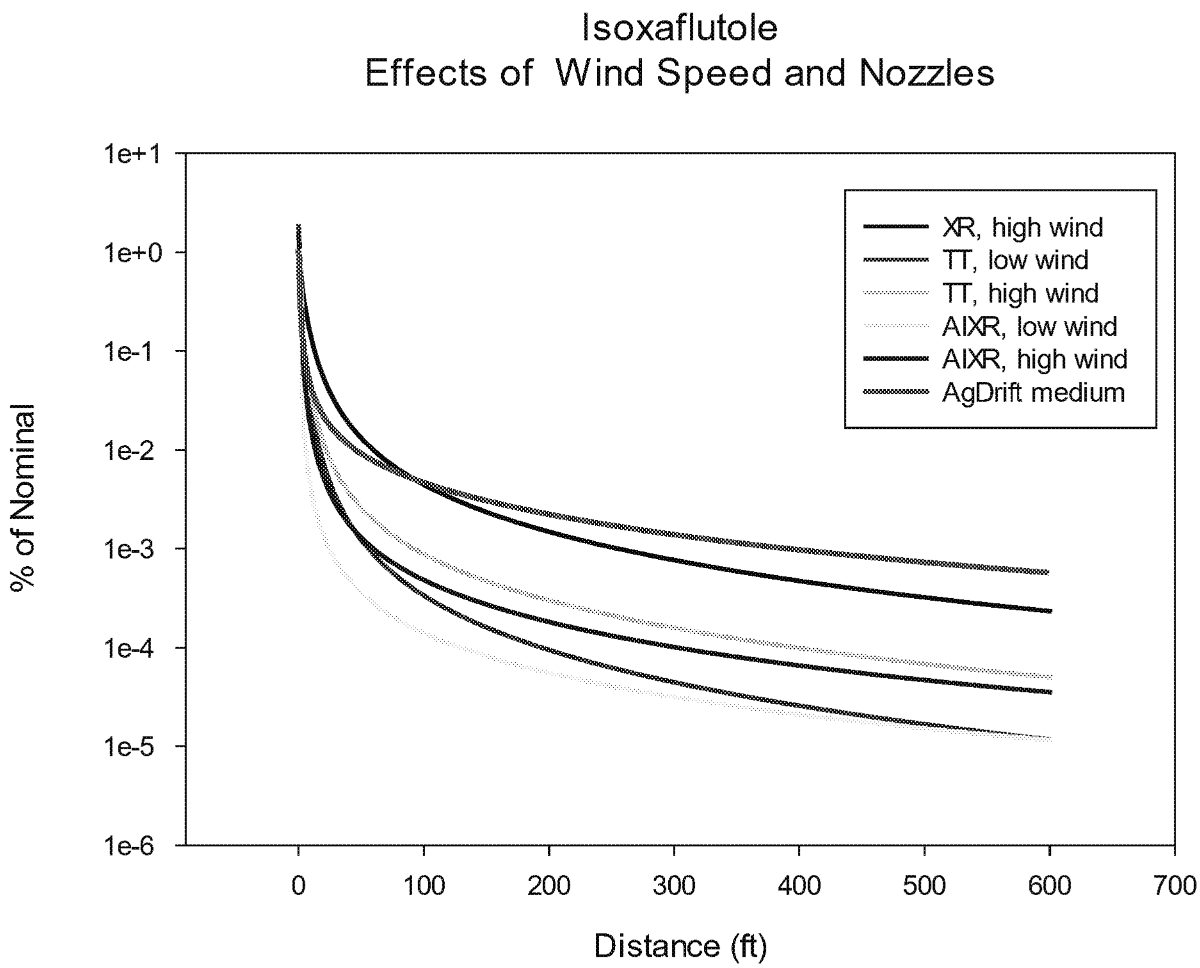

Figure 6. Spray drift deposition curve estimates for various wind speed and nozzle combinations from an isoxaflutole field spray drift study in Nebraska for a single swath. For comparison, the 90th percentile medium ground spray curve *with 3 swaths* from Ag Drift is included. (This is not the default AgDrift curve for ground spray).

A comparison of the data for the AIXR nozzle with high wind to the regressions estimate on the same data with 3 swaths is shown in **Figure** 7. A reference line for the toxicity of the most sensitive species, navy bean, is also on the graph. The estimate of deposition for the same nozzle and wind speed with 11 swaths, which is comparable to the default field width of 900 ft in Ag Drift shows that it is important to use a realistic number of swaths for the exposure estimate as there is a significant increase in the drift distance with the additional swaths, around 150 ft for navy beans in this case. Note that a square field 900 ft on each side would be about 18.7 acres which be small for soy bean field in most of the country. Recent registrant submissions have frequently used applications widths of 240 ft or less for their spray drift exposure assessments, and this graph illustrates that this approach is not reasonable or protective.

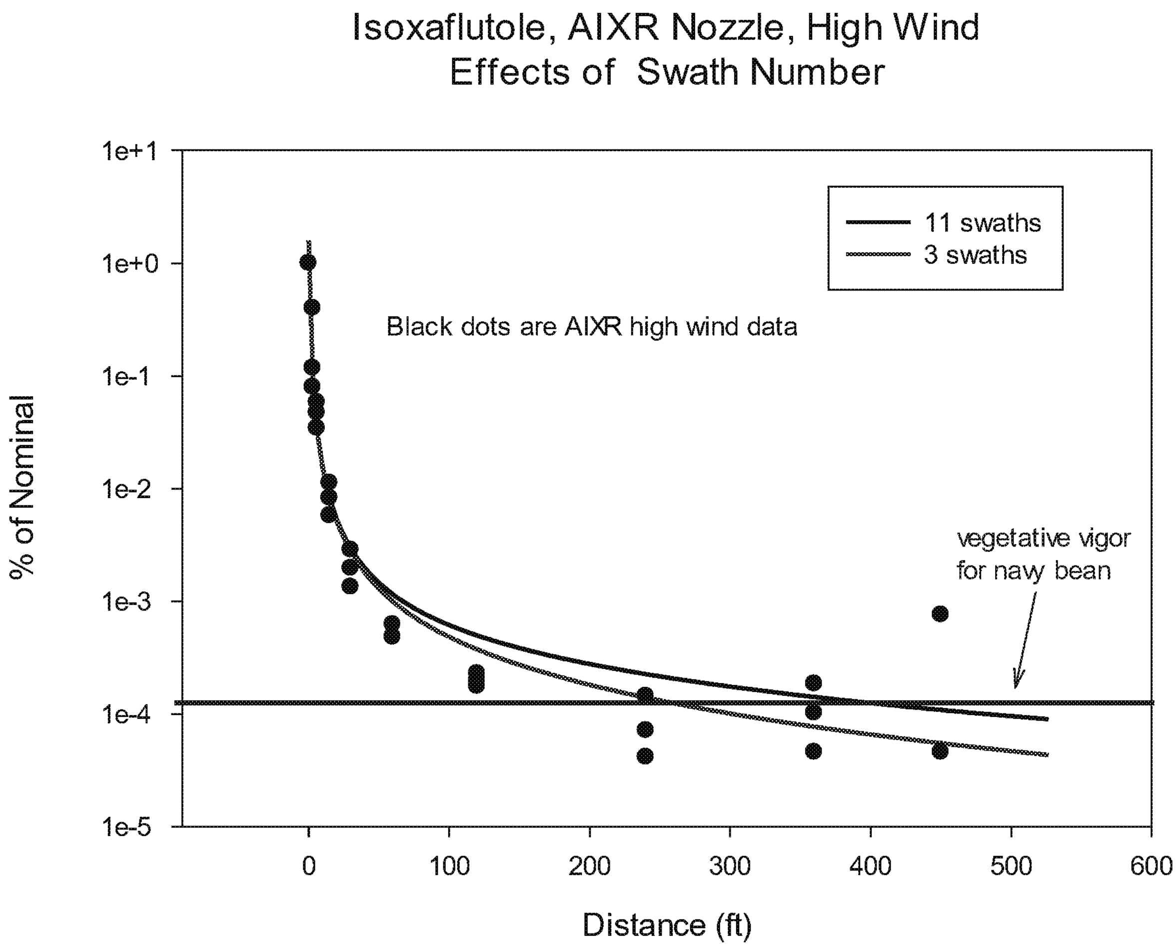

Figure 7. Comparison of data for high wind speed trial for AIXR nozzle with estimates based on two different swath numbers. The data set is comparable to the 3 swath trial. A full application to a field a comparison to regular AgDrift simulations is with 11 swaths.

Runoff Transport

Exposure of non-target plants to isoxaflutole transported via runoff is estimated via three different methods. The first is TerrPlant (v. 1.2.2)[5], EFED's standard model for terrestrial plants located in terrestrial and wetland habitats adjacent to treated fields. The second is a refined model, Audrey III, that relies upon runoff estimates from the Pesticide Root Zone Model (PRZM5[6]). A description of the Audrey III model equations is included in **Attachment 4**. In addition, the third method is consideration of concentrations of isoxaflutole and its phytotoxic degradate (RPA 202248) in runoff from two corn fields located in Illinois and Iowa (MRID 45129001). The exposure estimates generated for isoxaflutole and its phytotoxic degradate, RPA 202248, are compared to seedling emergence toxicity data because the seedling emergence study involves applications of the pesticide to the soil, which is representative of exposure via runoff.

TerrPlant

Runoff is estimated based on the solubility of the assessed chemical. The solubility of isoxaflutole is 6.2 ppm (MRID 43573205). Based on that, TerrPlant's estimated runoff exposure values are 0.00094 and 0.0094 lb a.i./A for terrestrial and wetland habitats, respectively.

As noted above, the solubility of isoxaflutole's degradate, RPA 202248, is 300 ppm. If 79% of the applied isoxaflutole is converted to this degradate[7], the runoff exposures for terrestrial and wetland habitats would be 0.0037 and 0.037 lb a.i./A, respectively for RPA 202248.

Audrey III

The Office of Pesticide Programs has a developed a provisional model for estimating exposure to terrestrial plants called Audrey III (**Attachment 4**). Audrey III is based on a new conceptual model (**Figure 8**) and uses PRZM to estimate runoff of a treated onto a Plant Exposure Zone (PEZ) where it is combined with loading from spray drift.

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[5] Details on this model are available online at:
http://www.epa.gov/oppefed1/models/terrestrial/terrplant/terrplant_user_guide.html
[6] Details on this model are available online at:
http://www.epa.gov/pesticides/science/efed/models/water/swcc/PRZM5.pdf
[7] This is the maximum amount observed from an aerobic soil metabolism study.

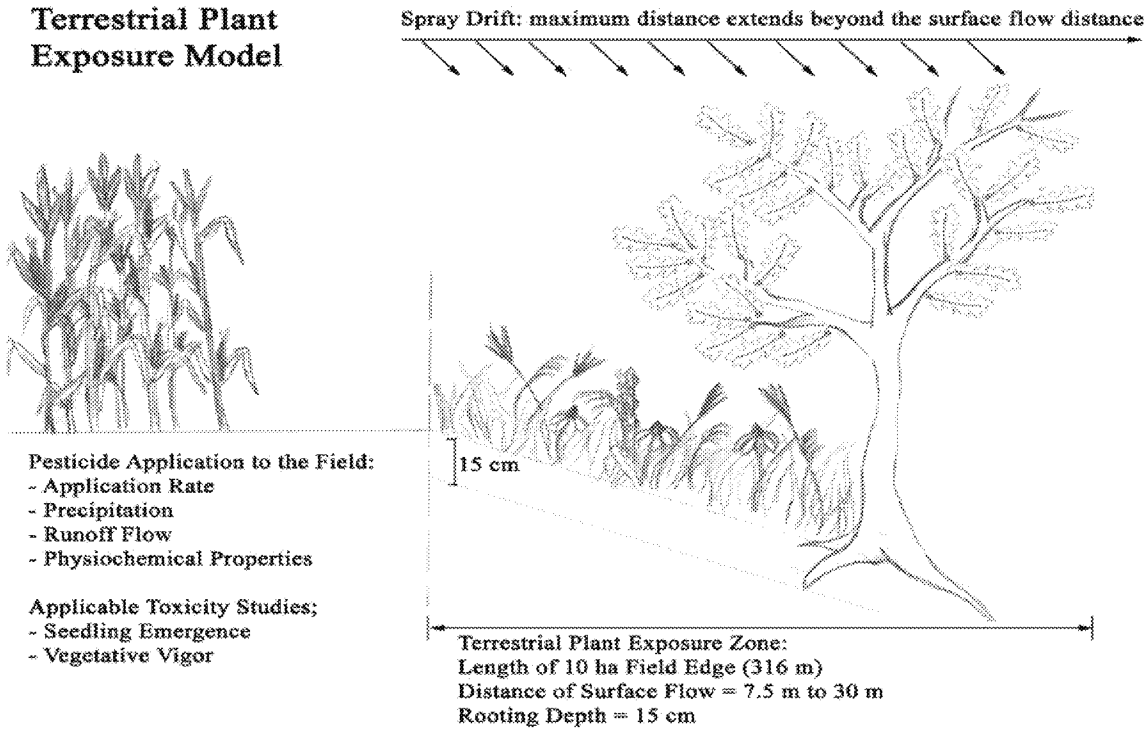

Figure 8. Conceptual model for Audrey III.

Loading from runoff is limited by the capacity of the PEZ to retain water and the width of the PEZ is limited to the area that can reasonably be assumed to maintain distributed overland flow. For this assessment, this width was assumed to be 50 ft.

The use pattern simulated for isoxaflutole (**Table 14**) was a single application made at the maximum rate, 0.0936 lb·acre^{-1} (0.105 kg·ha^{-1}) made as a pre-plant ground spray. For this assessment the spray was assumed to be very coarse, and the drift curve based on the very coarse nozzle (AIXR) from the field spray drift study (MRID 49414301).

Table 14. Label use rates for a new use of isoxaflutole as Balance Pro on soybeans

Crop	App. Rate (kg ha^{-1})	Number of annual applications[1] (interval)	Application Method	Label
Soybeans	0.105	1	preplant ground spray	Balance Pro (264-400)

The scenario chosen was the Mississippi soybean scenario which is a vulnerable scenario for runoff for soybeans relative all locations where soybeans are grown in the United States. Application was made each year on March 26, which was keyed to occur 21 days before the emergence date in the scenario, which is 1 week before planting.

Table 15. Scenario for Audrey III assessment of isoxaflutole on soybeans.

Crop	Scenario	Location	Soil	Weather	App Date
soybeans	MS soybean	Yazoo County, MS	Loring silt loam	Little Rock, AK	21 d before mergence

The chemistry input parameters for Audrey III are in **Table 16**. The parameters were chosen to represent the diketonitrile degradate, RPA 202248, as this degradate is more persistent and mobile than the parent and has similar toxicity. The parameters which relate to fate and transport in water bodies in the SWCC were not set as only the PRZM generated values from the surface water calculator were used in this assessment. The foliar degradation and foliar half-live values were set to default values, but are not relevant because application was made to bare soil and foliar degradation processes are not considered on the PEZ.

Table 16. Chemistry input parameters for isoxaflutole for use in Audrey III, and in PWC in support of Audrey III.		
Property	**Surface Water Modeling Parameter Value**	**Notes (see fate studies)**
Molecular Mass	359.3 $g \cdot mol^{-1}$	calculated
Aqueous Solubility	2877 mg L^{-1} @ 25° C	estimated with EpiSuite 4.1
Vapor pressure	1 x 10^{-6} torr	
Henry's Law Constant	1.84 x 10^{-10} $atm \cdot m^3 \cdot mol^{-1}$	
Aerobic Soil Metabolism half-life (days)	26 d @ 21° C	MRID 43588006[8] Upper 90% confidence bound on the mean of two studies
Foliar Degradation Rate	0 d^{-1}	default
Foliar Washoff Rate	0.5 cm^{-1}	default
K_{oc}	92 $L \cdot kg^{-1}$	MRID 44065801[9]

The current, provisional version of Audrey III is run in a spreadsheet using the equations described in **Attachment 4**. The runoff volume, and the mass of pesticide carried with the runoff, and on eroded sediment are taken from the 'ZTS' which is output of PRZM. PRZM version 5.0+ is run in the Pesticide Water Calculator is a shell that is used to manage input and output and run PRZM. The spray drift values were estimated from the curves for the AIXR nozzle with high wind speed. This assumes that the wind was blowing at 10 mph directly towards the PEZ during application of the pesticide.

The resulting concentration profile over 30 years is in **Figure 9**. The one-in ten year return concentration is 0.088 $kg \cdot ha^{-1}$. This 219 times higher than concentration due to spray drift alone at the mid-point (25 ft) of the PEZ of 4.0 x 10^{-4} $kg \cdot ha^{-1}$.

[8] Ferreira, E.M., M. K. Jones, and S.E. Newby. October 13, 1994. *Aerobic soil metabolism of RPA 201772.* Rhone Poulenc Project No. P 92/332. Unpublished study performed by Rhone Poulenc, Essex, England, and submitted by Rhone Poulenc, N.C.

[9] Burr, C. (1996) (Carbon 14)-RPA 202248: Adsorption/Desorption to and from Four Soils and an Aquatic Sediment: Lab Project Number: 11486: 201213. Unpublished study prepared by Rhone-Poulenc Agriculture Ltd. 124

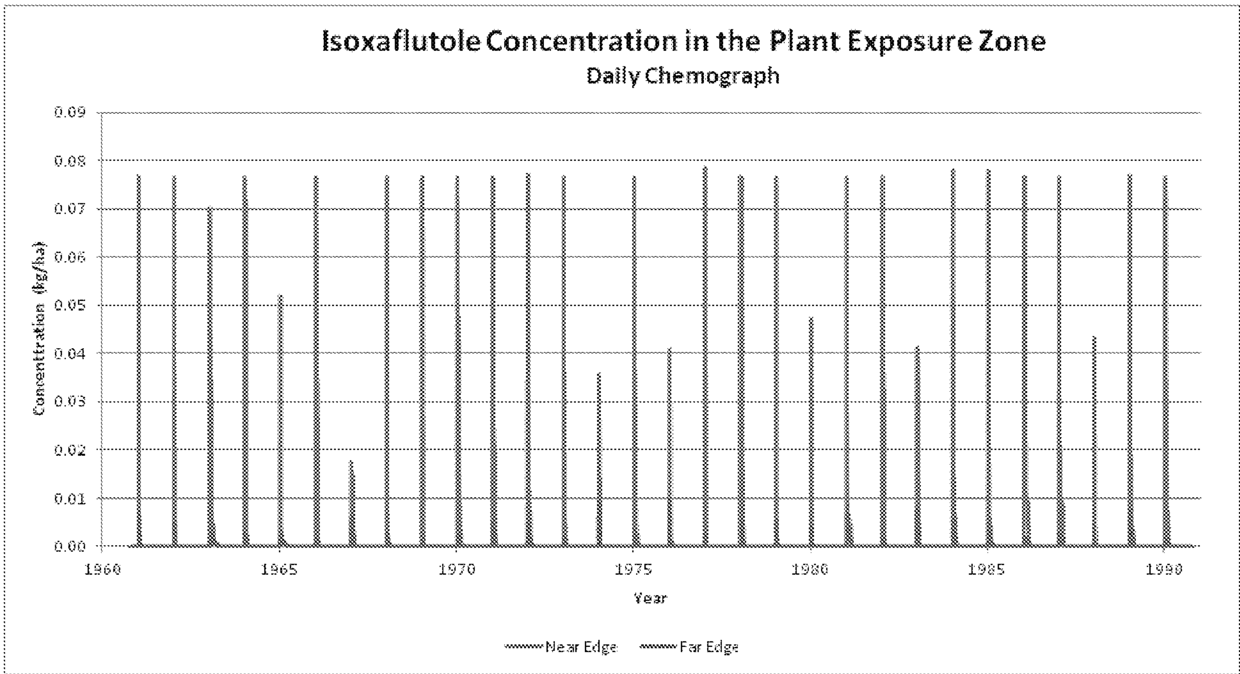

Figure 9. Isoxaflutole concentration as a function of time in the Plant Exposure Zone near a soy bean field in Mississippi as estimated using Audrey III, a plant exposure model.

Monitoring data

Two registrant submitted studies quantified the concentrations of isoxaflutole and its degradates in runoff from corn fields located in Iowa and Illinois (MRID 45129001). Balance was applied at a rate of 0.14 lb a.i./A isoxaflutole, which exceeds the proposed rate for this action (0.094). Measured concentrations of isoxaflutole + RPA 202248 were 0.5-37 ppb (µg/L). Most concentrations exceeded 10 ppb. In many samples, isoxaflutole and RPA 202248 were on the same order of magnitude, while in others, RPA 202248 concentrations were 1-2 orders of magnitude greater than isoxaflutole.

Risk Characterization

Risk to non-target plants is assessed for areas that are adjacent to the treated area. Exposure due to spray drift deposition is compared to endpoints for vegetative vigor and seedling emergence. Runoff exposure is compared to seedling emergence endpoints. Different endpoints are used to assess the risks of a pesticide to non-listed and listed plant species. For listed plant species, NOEC values for monocots and dicots are used. If a suitable NOEC is unavailable, an EC_{05} is used instead. For non-listed plant species, EC_{25} values for dicots and monocots are used. Risk conclusions based on EC25 values are also used to assess potential indirect effects to listed species that depend upon plants (e.g., animals that use plants for food or habitat). Since NOEC and EC_{05} values are more conservative than EC_{25} values, in cases where risks are identified for non-listed plants based on EC_{25} values, there would also be risk to listed plants. This section characterizes risks to non-target plants using NOEC, EC_{05}, and EC_{25} values, as well as other toxicity data that are available.

Spray Drift

As discussed previously, spray drift deposition is estimated using the AgDRIFT model and a registrant submitted spray drift study for isoxaflutole. The data from the drift study are limited in utility to the nozzles included in that study (*i.e.,* XR, TT and AIXR). Since nozzles are not specified on the proposed label for this action, AgDRIFT is used to represent spray drift exposure for all other nozzles.

Comparison to EC25 values

When considering spray drift deposition calculated using AgDrift[10], spray drift deposition representative of hundreds of feet from the edge of the field exceeds EC_{25} values for several different species of dicots (**Figure 10**). EC_{25} values representing 4 different dicot species (*i.e.,* cabbage, lettuce, navy bean, turnip), correspond to distances that are ≥500 feet. EC_{25} values for several additional species (beet, cotton, sunflower) fall between 100-500 feet of the edge of the field.

For the registrant spray drift study conducted with isoxaflutole, spray drift deposition is equivalent to the most sensitive dicot species (Navy Bean) at approximately 400 feet from the edge of the field (**Figure 10**). The next most sensitive species, *i.e.,* cabbage, has an EC_{25} equivalent to approximately 130 feet from the edge of the field.

This indicates that isoxaflutole poses a risk of decrease in ≥25% decrease in growth of several different dicot species located hundreds of feet from the edge of the treated field. This poses a risk of direct effects to dicot species and may alter plant communities by allowing unaffected species to outcompete the more sensitive species. This indicates that there is potential for indirect effects to listed species that depend upon plants and direct effects to listed species of dicots.

As indicated by **Figures 10 and 11,** risks of isoxaflutole to monocot species occurs within 25 feet from the edge of the field.

[10] 90^{th} percentile estimates from the Tier I ground tool of AgDrift (low boom, ASAE fine to medium/coarse)

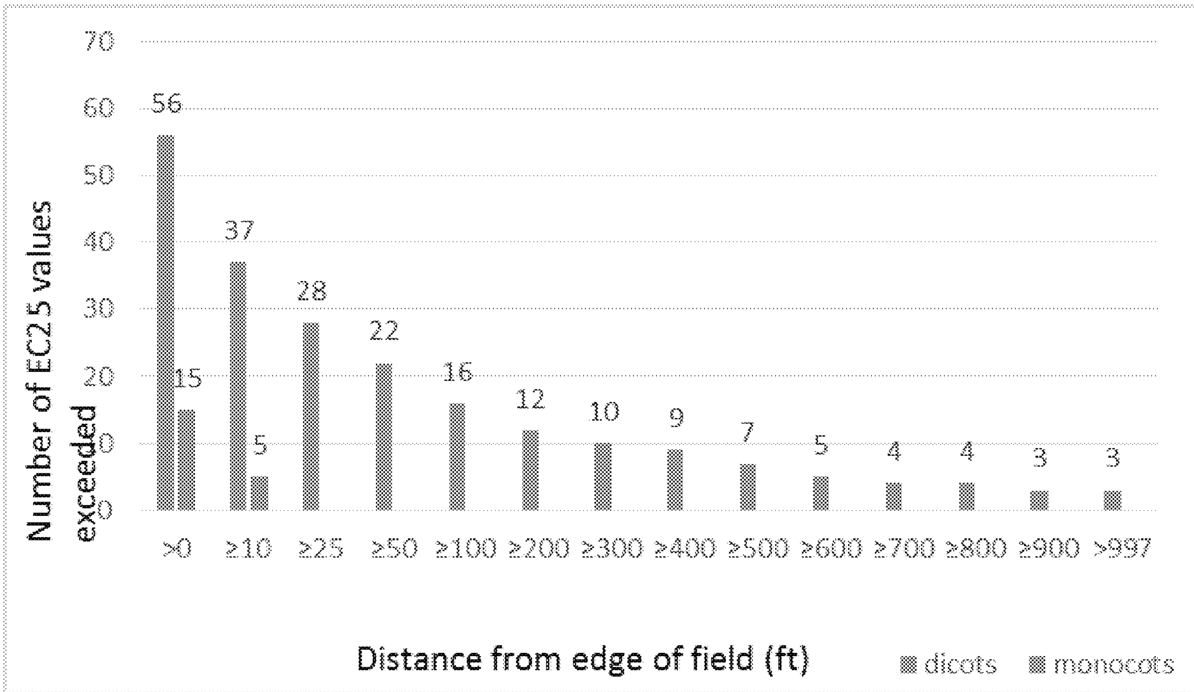

Figure 10. Number of Vegetative Vigor EC_{25} values at different distances from the edge of the field. Spray drift deposition based on AgDRIFT (Tier I ground analysis with low boom, ASAE fine to medium/coarse, 90th percentile deposition).

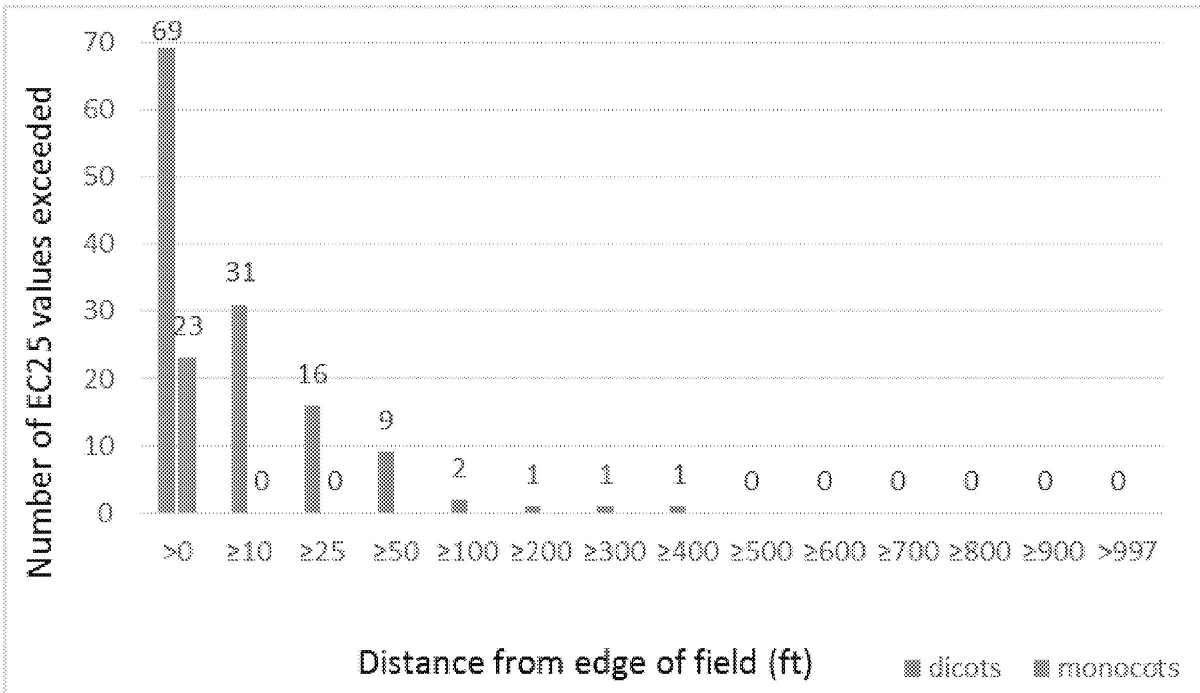

Figure 11. Number of Vegetative Vigor EC_{25} values at different distances from the edge of the field. Spray drift deposition based on spray drift study conducted with isoxaflutole.

Species sensitivity distributions

As noted in **Attachment 2**, species sensitivity distributions (SSDs) were developed using EC_{25} values from vegetative vigor and seedling emergence studies. When integrated with available spray drift data (*i.e.,* from AgDRIFT and from the registrant submitted study (MRID 49414301)), these data can be used to characterize the potential impacts of isoxaflutole on plants. **Figure 12** depicts a SSD of EC_{25} values based on shoot weight declines observed in 17 species during vegetative vigor studies (conducted with TGAI or Balance). Dotted lines on the graph provide information on spray drift distances representative of deposition equivalent to a particular point on the SSD. Spray drift distances are provided for both AgDRIFT (A; ground spray with low boom, medium to coarse droplets) and the registrant submitted drift study (R) for isoxaflutole.

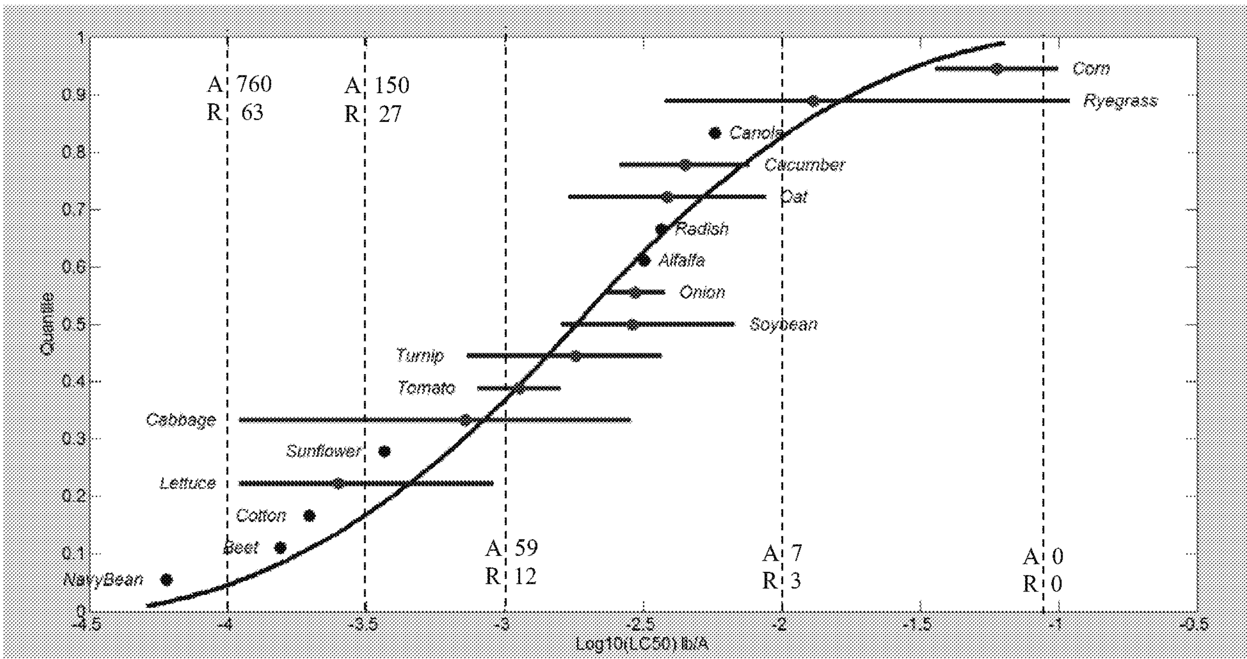

Figure 12. SSD for vegetative vigor EC_{25} values for shoot weight from studies involving Balance and TGAI. Solid line depicts best estimate of Triangular SSD. Black points represent single-species EC_{25} values. Red points represent geometric means for species where multiple EC_{25} are available (blue lines represent range). Dotted lines represent spray drift deposition at distances (in feet) from the edge of the field from AgDRIFT (A) and the registrant (R) submitted spray drift study.

Table 17 provides spray drift distances relevant to different percentiles of the SSDs for vegetative vigor effects to shoot height, shoot weight and root weight. When considering spray drift deposition estimates generated using the AgDRIFT model, risk to the 5th and 10th percentile species extend hundreds of feet from the edge of the field. When considering the registrant submitted drift deposition data, risk to the 5th percentile species extends as far as 140 feet from the edge of the field.

Table 17. Spray drift distances corresponding to percentiles of SSDs for different vegetative vigor endpoints. Separate calculations made for registrant submitted spray drift data and AgDRIFT model. SSDs include monocot and dicot EC25 values.

Endpoint	Drift data	Percentile species from SSD						
		5	**10**	**25**	**50**	**75**	**90**	**95**
root weight	AgDRIFT	>1000	550	140	25	3	0	0
	Registrant	140	72	27	10	4	1	1
shoot weight	AgDRIFT	>1000	400	90	20	4	1	0
	Registrant	76	44	20	9	4	2	1
shoot length	AgDRIFT	200	57	10	2	1	0	0
	Registrant	43	19	6	2	1	1	1

This indicates that isoxaflutole poses a risk of decrease in ≥25% decrease in growth of sensitive dicot species located hundreds of feet from the edge of the treated field. Therefore, there is potential for indirect effects to listed species that depend upon plants. This also suggests concerns for listed dicots that are located hundreds of feet from the edge of the treated field. The 5^{th} percentile of an SSD is often used to set protection levels for non-target species; however, the endpoint for listed plants is <25% effects (25% effects would represent an adverse effect for a listed plant). Therefore, a more conservative endpoint than the 25% effect level from the 5^{th} percentile of an SSD would be needed for listed plants. The next section discusses the comparison of spray drift exposure to NOECs, which are the endpoints used to assess risks to listed plants.

Comparison to NOEC, LOEC and EC05 values

When considering AgDRIFT deposition, the risks to listed species of dicots exposed to isoxaflutole spray drift deposition extend to the limit of the model, *i.e.,* >997 feet from the edge of the treated field. NOEC or EC_{05} values for three dicot species (lettuce, turnip and radish) correspond to spray drift deposition exposure that is >997 feet (**Figure 13**). LOEC values for lettuce also correspond to spray drift deposition >997 feet. In addition, LOEC values for beet, cotton and turnip are ≥300 feet.

When considering the spray drift field study with isoxaflutole, the most conservative NOEC values (for lettuce) are equivalent to distances >400 feet from the edge of the field, with LOEC values at approximately 150 feet (**Figure 14**). Risks to turnip and radish extend 150 and 120 feet from the edge of the field.

In summary, when considering endpoints used for listed dicots (*i.e.,* most sensitive NOECs), risks extend at least 460 feet for the isoxaflutole study and >997 feet when considering AgDRIFT output. When considering other endpoints that are less sensitive (*i.e.,* LOECs), risks extend 150 feet based on the isoxaflutole study and >997 feet based on AgDRIFT. This information indicates that listed dicot species are at risk of effects from isoxaflutole in areas that are located hundreds of feet from the edge of a treated field.

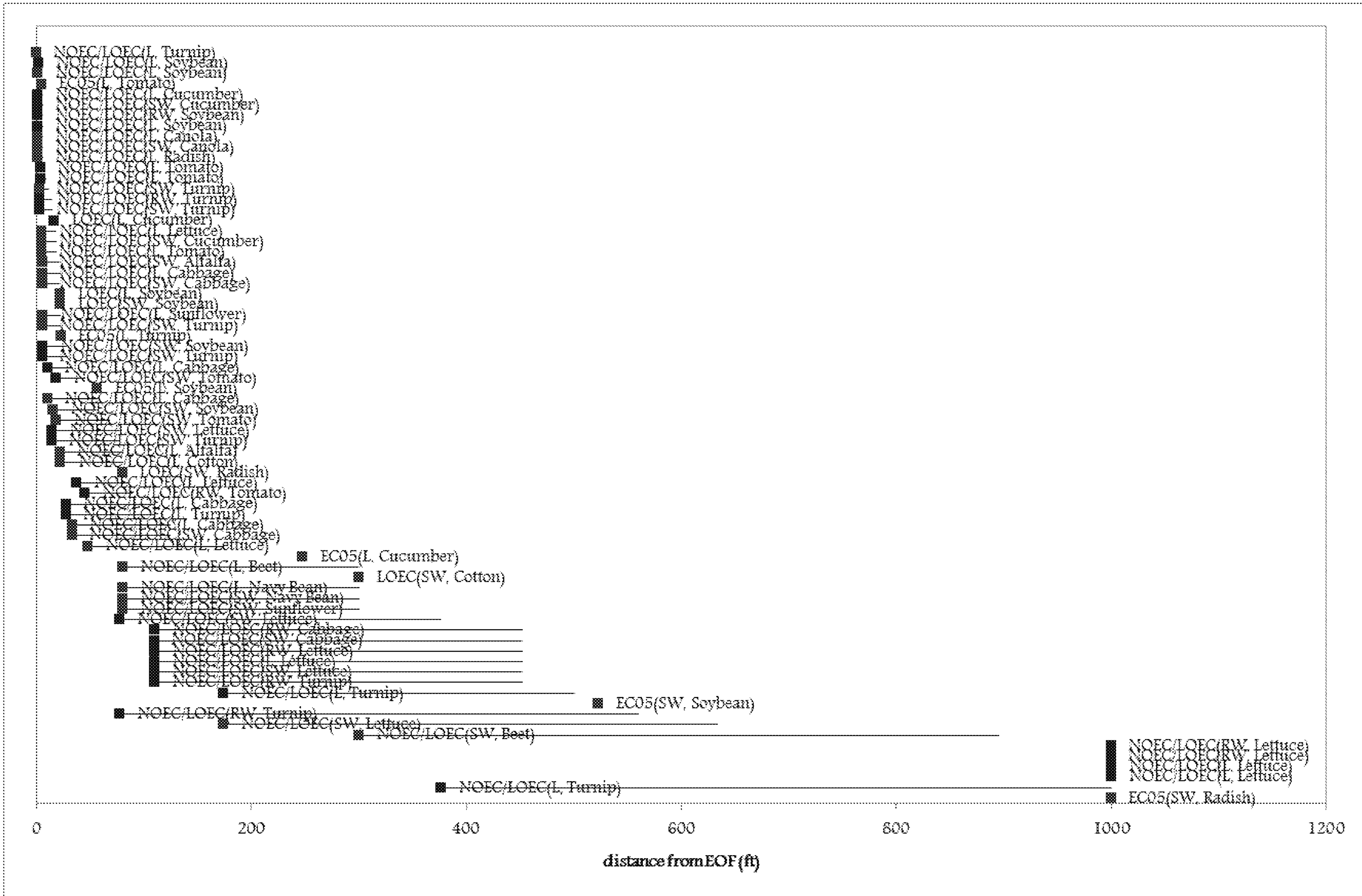

Figure 12. Spray drift deposition (AgDRIFT) corresponding to NOEC/EC05 and LOEC endpoints available for dicots from greenhouse vegetative vigor and seedling emergence endpoints. SW = shoot weight, RW = root weight, L = length/height. Blue points = TGAI, Red points = Balance.

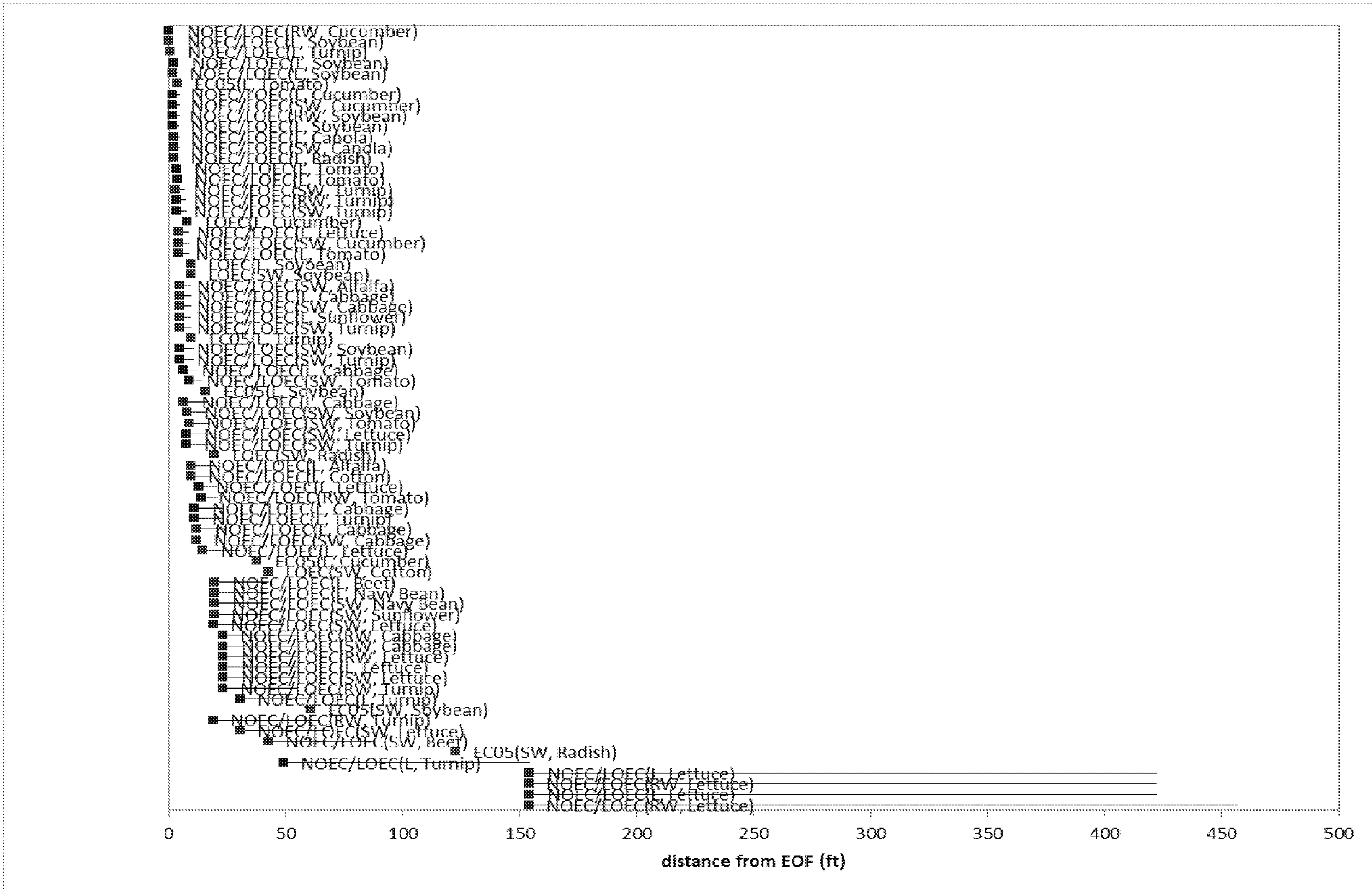

Figure 13. Spray drift deposition (from study involving isoxaflutole) corresponding to NOEC/EC_{05} and LOEC endpoints available for dicots from greenhouse vegetative vigor and seedling emergence endpoints. SW = shoot weight, RW = root weight, L = length/height. Blue points = TGAI, Red points = Balance.

Field studies

Of the available field studies, effects to cotton were most pronounced. In all 6 studies, Balance was applied at a rate of 0.0014 lb a.i./A isoxaflutole. Using the AgDRIFT model, this is equivalent to the deposition rate at 23 feet from the edge of the field. In this study, a 22% reduction in seed yield was observed, along with a slight reduction in height and phytotoxicity. These data appear to be consistent with the vegetative vigor study available for cotton (MRID 45658802), where a LOEC for height was established at 0.00155 lb a.i./A.

Runoff

TerrPlant

Runoff exposure estimates in wetland habitats (0.0094 lb a.i./A) exceed several endpoints available for Balance (**Figure 15**). The estimated exposure in wetlands exceeds EC_{25} values for cabbage and lettuce. Estimated exposure also exceeds NOEC/EC_{05} values for dicots (cabbage, lettuce, turnip, tomato) and monocots (ryegrass, onion). LOECs are also exceeded for several species (**Table 4**). This indicates that runoff transport of isoxaflutole to wetland areas poses a risk to listed plants as well as non-target dicot plants, with could also lead to indirect effects to animals that depend upon these plants.

Runoff exposure estimates in terrestrial habitats (0.00094 lb a.i./A) do not exceed endpoints available for Balance (**Figure 15**). Although EC_{25} values available for TGAI are exceeded, there is uncertainty associated with using these values for seedling emergence effects since the SSD analysis suggests that there are differences in toxicity of the TGAI and Balance (for seedling emergence, not vegetative vigor). Estimated exposure also exceeds and EC_{05} value for cucumber. Therefore, there is potential for effects to listed dicots due to runoff; however, indirect effects to species relying upon terrestrial plants are not indicated for runoff exposure.

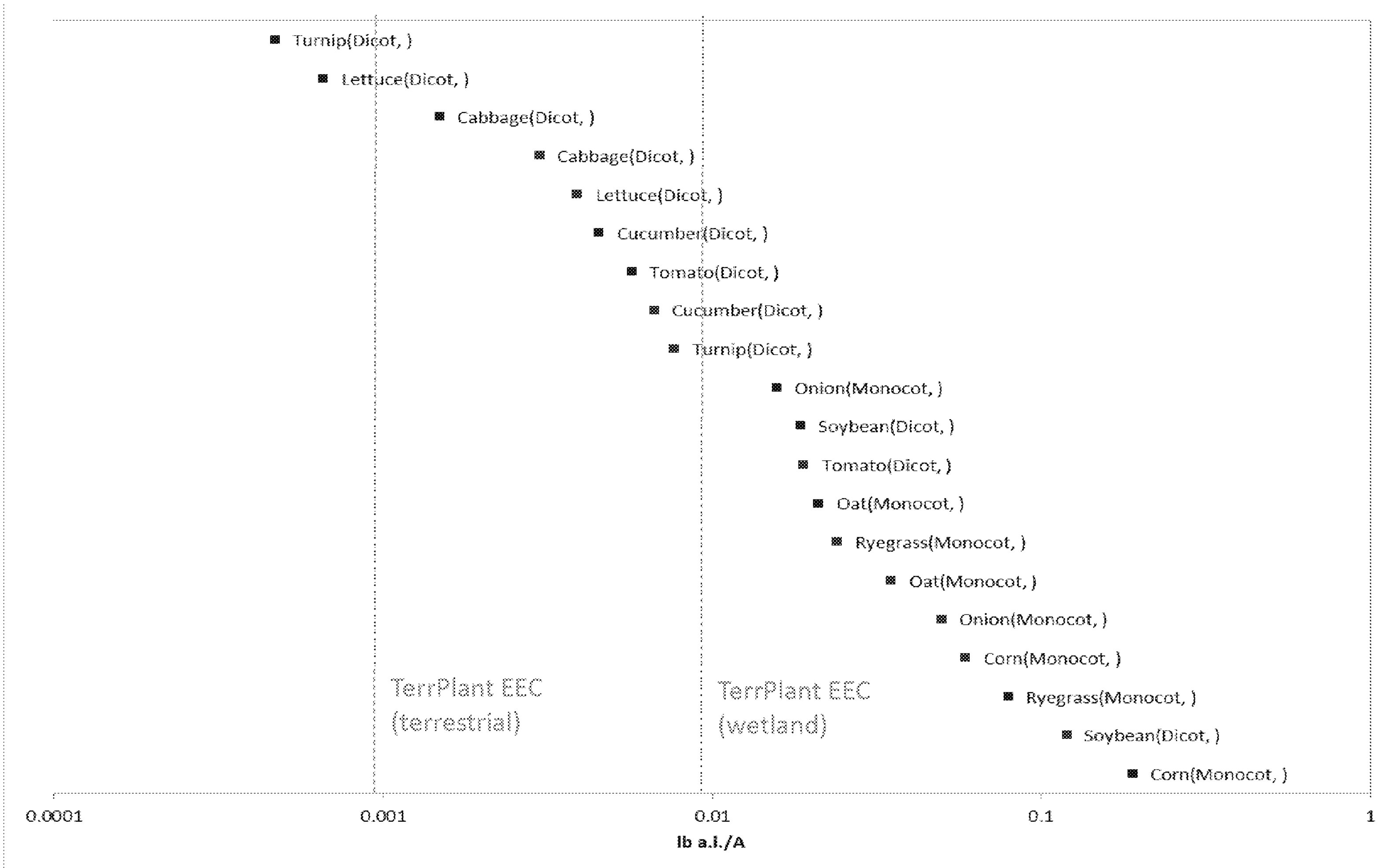

Figure 15. Comparison of runoff exposure estimates (dotted lines) and seedling emergence EC_{25} values (blue = TGAI, red = Balance).

Audrey III

While Audrey III is not the Agency's official tool for assessing exposure to plants, it can be used to supplement the characterization of terrestrial risk to plants that may be identified using TerrPlant. Future versions of Audrey III will address exposure in wetlands and aquatic environments. Audrey III advantages as compared to TerrPlant include a more clearly constructed conceptual model which is related to the conceptual model used for other environmental exposure assessments for pesticides, the ability to combine runoff and spray drift routes of exposure, to the capability assess how risk changes with location and crop, and to see how the exposure varies with time at a given site.

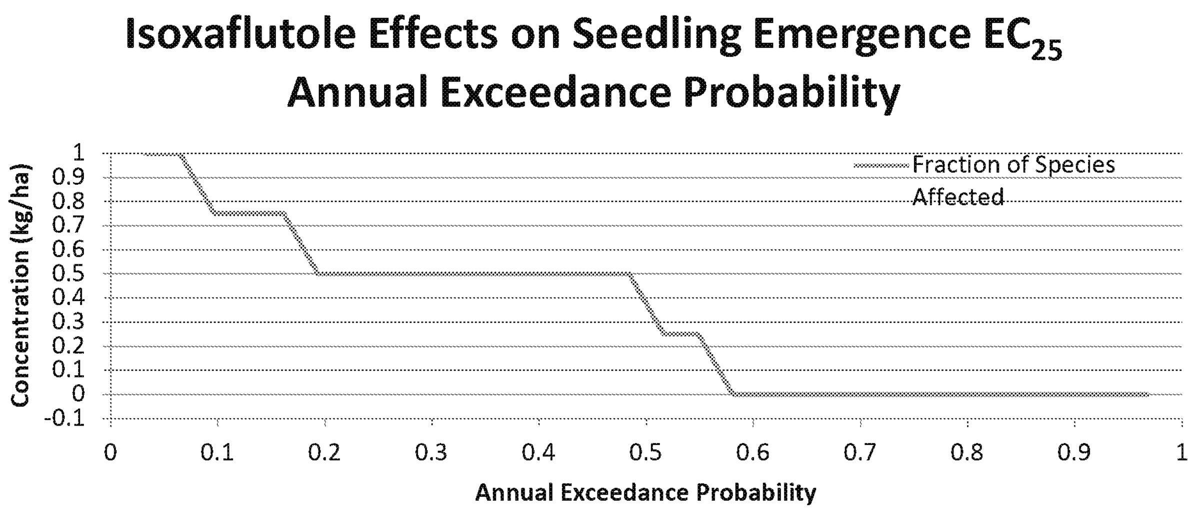

Figure 14. Fraction of species affected at the EC_{25} by isoxaflutole at the maximum annual soil concentration in the PEZ as estimated by Audrey III in a Mississippi soy bean field.

To estimate with risk with Audrey III output, the annual maximum series was estimated for the chemograph in **Figure 9**. An annual maximum series identifies the maximum concentration found in each year, and sorts them from greatest to least. A probability of occurrence is calculated as the rank divided by the total number of years plus one. For each annual maximum concentration, the fraction of the number of seedling emergence EC_{25} values (19 values total) which were exceeded by the annual maximum were tabulated and then plotted (**Table 16**). This gives some conception of fraction of total species which may be affected by isoxaflutole in the zone near the field where distributed runoff occurs. In two years out of 30, 90% of germinating seeds may be affected in the PEZ, according to this analysis. In half the years, 50% of the species could be affected and 20% of the species were affected in every year. These results are, in fact somewhat similar to those for TerrPlant above, using the same toxicity data, but the time dimension in Audrey III allows a better conception of the frequency with which adverse effects may be occurring. For comparison purposes, the risk quotient for isoxaflutole to the most sensitive species in this set of data and the 1-in-10 year peak EEC is 16.3. Across the entire 30 year simulation, the EC_{25} for the most sensitive species was exceeded for 6.4% of the time, or about 23 days a year.

Monitoring data

In registrant submitted studies conducted in Iowa and Illinois, most concentrations of isoxaflutole + RPA 202248 exceeded 10 ppb, with a range of 0.5-37 ppb. The application rate of this study was 0.14 lb a.i./A, which is 67% of the proposed application rate for the current action (0.94 lb a.i./A). If it is assumed that the concentrations measured in runoff are proportional to the application rate, the adjusted concentrations would be a range of 0.3-25 ppb, with most concentrations exceeding 6.7 ppb. These values are above the EC50 value available for vascular aquatic plants[11] exposed to isoxaflutole (4.9 ppb; MRID 43573246) but below the EC50 for RPA 202248 (75 ppb; MRID 44399909). Several concentrations of isoxaflutole (alone) in runoff exceed the EC50 for isoxaflutole, as well as the NOEC (1.1 ppb). This indicates that runoff exposure to isoxaflutole could potentially impact the growth of plants of listed and listed plants.

Incident reports

Since isoxaflutole was registered, hundreds of incidents to plants have been reported in EIIS and thousands of incidents have been reported in the aggregate database. A large portion of these incidents have involved Balance. The majority of the reported incidents have involved damage associated with direct applications to corn according to the label.

The majority of the other incidents are associated with carryover of isoxaflutole (and likely its phytotoxic degradate), which caused damage to the crop planted the season after the original application of isoxaflutole. This suggests that isoxaflutole residues are phytotoxic for months after the application.

A limited number of incidents are available involving runoff and spray drift transport; however, a lack of reporting of incidents does not necessarily indicate that incidents do not occur in the field.

Federally-listed endangered and threatened species

LOCATES was run on 4/21/15 to identify species which co-occur with soybeans in the states that are considered for this proposed use. This analysis indicates that a total of 96 plants and 256 animals potentially overlap with areas where soybeans are grown (or the areas adjacent to the fields). Based on this risk assessment, there are concerns for direct effects to 75 dicot species that could be located within hundreds of feet of a soybean field. There are concerns for direct effects to 14 listed monocot species that could potentially be located within 25 feet from the edge of the field (**Table 18**). There are also concerns to 7 other types of plants potentially receiving spray

[11] These exposure data are compared to aquatic plant endpoints because the values are expressed as a concentration in water.

drift within hundreds of feet of the field (since no data are available for ferns, conifers and lichens, it is assumed that they are of similar sensitivity as dicot species) (**Table 18**). There are an additional 256 listed animal species that could potentially be indirectly affected by applications of isoxaflutole that impact plants (*e.g.*, decrease in availability of food or suitability of habitat; **Table 19**). **Attachment 5** includes the list of specific species that are of concern. Based on the results of this risk assessment, a "may affect" determination should be made for the 352 species listed in **Attachment 5**.

Table 18 Number of listed plant species with potential direct effects concerns.

Taxa	Number of species
Dicot plants	75
Monocot plants	14
Ferns (plants)	5
Conifers/cycads (plants)	1
Lichen (plants)	1
total	96

Table 19. Number of listed animal species with potential indirect effects concerns.

Taxa	Number of species
Mammals	23
birds	21
Amphibians	8
Reptiles	13
Fish	57
Crustaceans	8
bivalves	87
Gastropods	18
Arachnids	7
Insects	14
total	256

Conclusions

At distances that are hundreds of feet from the field, sensitive species of dicots are at risk to decreases in growth due to spray drift deposition. There is concern for direct effects to plants as well as indirect effects. There are substantial concerns for impacts to the integrity of plant communities, and species which depend upon plants for food and shelter. These conclusions are based on the following:

1) for spray drift deposition generated using the AgDRIFT model,

a. deposition estimates exceed EC_{25} values representing 4 different dicot species (*i.e.,* cabbage, lettuce, navy bean, turnip), at distances that are ≥500 feet from the edge of the treated field;
b. the 5th percentile of the SSD of EC25 values indicates a risk to sensitive species at distances >1000 feet from the edge of the field field;
c. deposition at the bounds of the model (*i.e.,* 997 ft) is above NOEC and EC05 values for two species (lettuce and turnip);
d. deposition at the bounds of the model (*i.e.,* 997 ft) is above LOEC values for the most sensitive species (lettuce);

2) for spray drift deposition from the registrant-submitted study with isoxaflutole,
   a. deposition estimates exceed the most sensitive dicot EC_{25} (navy bean) at 400 feet from the edge of the treated field;
   b. the 5th percentile of the SSD of EC25 values is equivalent to deposition at 140 feet from the edge of the field;
   c. deposition at 460 feet from the field is equivalent to the most sensitive NOEC (for lettuce);
   d. deposition at 150 feet from the field is equivalent to the most sensitive LOEC (for lettuce);

In addition, near the treated field (within 25 feet), spray drift deposition poses a risk of decrease of growth of monocots.

In this assessment, exposure to non-target plants via spray drift deposition is estimated using two different methods, *i.e.,* AgDRIFT and a registrant drift study. The data from the drift study are limited in utility to the nozzles included in that study (*i.e.,* XR, TT and AIXR). Since nozzles are not specified on the proposed label for this action, AgDRIFT is used to represent spray drift exposure for all other nozzles.

Estimated exposures from runoff transport are also of concern for risks to dicot species, indicating potential impacts to plants inhabiting terrestrial and wetland habitats that receive runoff from treated fields.

Thousands of incidents of effects to plants have been reported following applications of isoxaflutole. Although the majority of these incidents involve effects to corn following direct applications made according to the label, many incidents have also been reported following carryover of phytotoxic residues from previous growing seasons. This is of concern because it suggests that isoxaflutole residues can pose a risk for long periods of time (months) after being applied.

In regards to federally listed endangered and threatened species, isoxaflutole poses a risk of direct effects to listed dicot plants located within 1000 feet from the edge of the field. There is also potential for indirect effects to other plants that inhabit communities containing dicots as well as animals that depend upon plants for food or shelter. In the states included in this action, there are 75 listed species of dicots, 21 listed species of other listed plants and 256 listed species of listed animals.

Citations

D284037. Eckel, William P. 2002. *Review of Final Study Report on Tile Drain Study for Isoxaflutole in New Holland, Ohio*. Internal EPA Memorandum to Dan Kenny, dated August 21, 2002.

D287767. Eckel, William. 2003. *Isoxaflutole Monitoring Data From Missouri Reservoirs Up To March, 2003*. Internal EPA Memorandum to Joanne Miller, dated May 27, 2003.

D382078. Shaughnessy, William. 2011. Isoxaflutole: Drinking Water Exposure Assessment of Section 3 New Use on Soybeans and on Corn in Five Additional Southern States. Internal EPA Memorandum to Kathryn Montague, dated January 11, 2011.

Attachment 1. Bibliography of registrant-submitted terrestrial plant toxicity studies involving isoxaflutole and its degradates.

MRID	Citation Reference	Comments
43573242	Hoberg, J. (1994) RPA 201772--Determination of Effects on Seed Germination, Seedling Emergence, and Vegetative Vigor of Ten Plant Species: Lab Project Number: 94-4-5234: 10566.0194.6326.610. Unpublished study prepared by Springborn Labs, Inc. 347 p.	Data included in effects characterization. Test material was TGAI.
44291501	Hoberg, J. (1997) RPA 201772--Determination of Effects on Seed Germination, Seedling Emergence, and Vegetative Vigor of Ten Plant Species: **Supplemental Report to MRID 43573242**: Lab Project Number: 94-4-5234: 10566.0194.6326.610. Unpublished study prepared by Springborn Labs, Inc. 77 p.	Supplemental data for MRID 43573242.
44399905	Teixeira, D. (1997) RPA 201772--Determination of Effects on Vegetative Vigor of Three Plant Species: Final Report: Lab Project Number: 97-9-7076: 10566.0797.6432.610: 072397/EPA/610/SAND/RP/RPA 201772. Unpublished study prepared by Springborn Labs., Inc. 125 p.	Data included in effects characterization. Test material was TGAI.
44399906	Teixeira, D. (1997) RPA 203328--Determination of Effects on Vegetative Vigor of Ten Plant Species: Final Report: Lab Project Number: 97-9-7082: 10566.0797.6442.610: 072997/VV/RPA-203328. Unpublished study prepared by Springborn Labs., Inc. 139 p.	Data included in effects characterization. Test material was TGAI of terminal degradate (203328).
44399907	Teixeira, D. (1997) RPA 203328--Determination of Effects on Seedling Emergence of Ten Plant Species: Final Report: Lab Project Number: 97-9-7068: 10566.0797.6440.610: 072997/FIFRA/SE/RPA-203328. Unpublished study prepared by Springborn Labs., Inc. 137 p.	Data included in effects characterization. Test material was TGAI of terminal degradate (203328).
44839702	Teixeira, D. (1998) Balance--Determination of Effects on Seedling Emergence of Nine Plant Species: Final Report: Lab Project Number: 98-11-7540: 10566.0898.6515.610. Unpublished study prepared by Springborn Laboratories, Inc. 155 p.	Data included in effects characterization. Test material was Balance.
44839705	Parsons, R.G. (1999) Nontarget Plant Field Study: RPA02248: Effect of Irrigation Contamination on a Range of Crops. Rhone Poulenc Research Farm, Essex, England.	Study not used. Classification is invalid.
44839706	Cappy, J. (1999) Established Soybean Irrigated with Water Containing RPA202248: Final Study Report: Lab Project Number: 98715936: 45719: 45390. Unpublished study prepared by Rhone-Poulenc Ag Company. 123 p.	Study not used. Classification is invalid.
44896901	Ortego, L. (1999) Balance Terrestrial Plant Testing-Seedling Emergence Summary: Lab Project Number: LSO/0899-LE. Unpublished study prepared by Rhone-Poulenc Ag Co. 6 p.	Submission not used because it is a summary. Does not include raw data.
44896902	Chetram, R. (1999) Tier 2 Definitive Seedling Emergence Nontarget Phytotoxicity Study Using Balance: Lab Project Number: 99816. Unpublished study prepared by ABC Labs. 71 p.	Data included in effects characterization. Test material was Balance.
44896903	Ortego, L. (1999) **Balance** Terrestrial Plant Testing (Vegetative Vigor) and **Revised Risk Assessment**: Lab Project Number: LSO/0899-VV. Unpublished study prepared by Rhone-Poulenc Ag Co. 8 p.	Submission not used because it is a summary. Does not include raw data.
44896904	Teixeira, D. (1999) Balance--Determination of Effects on Vegetative Vigor of Three Plant Species: Lab Project Number: 15931: 10566.0698.6504.610. Unpublished study prepared by Springborn Labs. 109 p.	Data included in effects characterization. Test material was Balance.
44896905	Teixeira, D. (1998) RPA 201772--Determination of Effects on Vegetative Vigor of Three Plant Species Conducted in Sandy Loam: Final Report: Lab Project Number: 97-11-7139: 10566. 0797.6443.610. Unpublished study prepared by Springborn Labs. 125 p.	Data included in effects characterization. Test material was TGAI.

MRID	Citation Reference	Comments
44896906	Ortego, L. (1999) Balance--The Use of Vegetative Vigor Testing to Estimate Irrigation Effect Levels: Lab Project Number: LSO/0899-IEL. Unpublished study prepared by Rhone-Poulenc Ag Co. 6 p.	Irrigation study. Not used in assessment.
44906501	Chetram, R. (1999) Tier 2 Definitive Vegetative Vigor Nontarget Phytotoxicity Study Using Balance: Lab Project Number: 99815: 45423. Unpublished study prepared by ABC Laboratories California. 167 p.	Data included in effects characterization. Test material was Balance.
44931401	Tank, S. (1999) Monitoring Terrestrial Drift and Run-Off Zones for Non-Target Plant Response to a Label-Rate, Pre-Emergence Application of Balance WDG Herbicide to Cornfields: **Lab Project Number: 079811**. Unpublished study prepared by Ecotoxicology and Biosystems Associates, Inc. 49 p.	Preliminary results for MRID 45129001. Since this is not the final report, these results are not used.
45022401	Tank, S. (2000) Monitoring Terrestrial Drift and Run-Off Zones for Non-Target Plant Response to a Label-Rate, Pre-Emergence Application of Balance WDG Herbicide to Cornfields: Field Study Interim Report: **Lab Project Number: 079811**. Unpublished study prepared by Ecotoxicology and Biosystems Associates, Inc. 55 p.	Preliminary results for MRID 45129001. Since this is not the final report, these results are not used.
45129001	Tank, S.; Brewer, L.; Cook, S. et al. (2000) Monitoring Terrestrial Drift and Run-Off Zones for Non-Target Plant Response to a Label-Rate, Pre-Emergence Application of Balance WDG Herbicide to Cornfields: Final Report: **Lab Project Number: 079811**: EBA079811: 103-001. Unpublished study prepared by Ecotoxicology and Biosystems Associates, Inc. 594 p.	Field study used for characterization of exposure due to runoff. Test material was Balance. Phytotoxicity observations not used because they were considered "deeply flawed" by EFED reviewer (Memo dated 6/7/01, DP barcode 266715).
45244501	Cappy, J. (2000) Cotton Irrigated with Water Containing RPA202248: Lab Project Number: 99716969: B003000: 46037. Unpublished study prepared by Aventis CropScience and South Texas Ag Research. 163 p.	Used for characterization of effects due to contaminated irrigation water. Study conducted with phytotoxic degradate (RPA 202248).
45244502	Cappy, J.J. (2000?) Established Soybean Irrigated with Water Containing RPA202248.Laboratory: Aventis CropScience, 2T.W. Alexander Drive, Research Triangle Park, NC 27709 (Water Sample Analysis). Midwest Research, Inc. RR 1 Box 107A, York, NE 68467 (Field Component). Springborn, Laboratories 790 Main Street, Wareham, MA 02571 (Seed Germination Testing). Agvise Laboratories, Highway 15 PO Box 510, Northwood, ND 58267 (Soil Sample Analysis). Sponsor: Aventis CropScience, 2T.W. Alexander Drive, Research Triangle Park, NC 27709. Laboratory Report ID: 9917752.	Study not used. Classification is invalid.
45244503	Cappy, J. (2000) Established Sunflower Irrigated with Water Containing RPA202248: Final Study Report: Lab Project Number: B003003: 99717755: 13726.6124. Unpublished study prepared by Aventis CropScience and Midwest Research Inc. 200 p.	Study not used. Classification is invalid.
45244504	Cappy, J. (2000) Effect of Simulated Isoxaflutole Drift on Canola: Final Study Report: Lab Project Number: 99717762: B003007: 13726.6124. Unpublished study prepared by Aventis CropScience and Midwest Research Inc. 84 p.	Field study used in characterization. Test material was Balance.
45244505	Cappy, J. (2000) Effect of Simulated Isoxaflutole Drift on Cotton: Final Study Report: Lab Project Number: 99717757: B003043: 17757-01. Unpublished study prepared by Aventis CropScience and G&H Associates. 40 p.	Field study used in characterization. Test material was Balance.

MRID	Citation Reference	Comments
45244506	Cappy, J. (2000) Effect of Simulated Isoxaflutole Drift on Rice: Final Study Report: Lab Project Number: 99716970: B003001: 13726.6124. Unpublished study prepared by Aventis CropScience and G&H Associates. 87 p.	Field study used in characterization. Test material was Balance.
45244507	Cappy, J. (2000) Effect of Simulated Isoxaflutole Drift on Spring Oats: Final Study Report: Lab Project Number: 99717759: B003008: 13726.6124. Unpublished study prepared by Aventis CropScience and Midwest Research Inc. 87 p.	Field study used in characterization. Test material was Balance.
45244508	Cappy, J. (2000) Effect of Simulated Isoxaflutole Drift on Soybean: Final Study Report: Lab Project Number: 99717761: B003006: 13726.6124. Unpublished study prepared by Aventis CropScience and Midwest Research Inc. 90 p.	Field study used in characterization. Test material was Balance.
45244509	Cappy, J. (2000) Effect of Simulated Isoxaflutole Drift on Sunflower: Final Study Report: Lab Project Number: 99717760: B003005: 13726.6124. Unpublished study prepared by Aventis CropScience and Prairie Ag Research, Inc. 87 p.	Field study used in characterization. Test material was Balance.
45244510	Parsons, R. (2000) RPA202248: Effect of Irrigation Contamination on a Range of Crops: Lab Project Number: FRE 99/01 GOOD 17949: 202594: FRE99/01. Unpublished study prepared by Aventis CropScience UK Limited. 74 p.	Used for characterization of effects due to contaminated irrigation water. Study conducted with phytotoxic degradate (RPA 202248).
45496901	Cappy, J.; Kelly, I.; Theissen, R. (2001) Balance Herbicide: Summary of Non-Targeted Crop Irrigated with Water Containing RPA 202248: Lab Project Number: B003467: 99716969: 99717752. Unpublished study prepared by Aventis CropScience. 73 p.	Irrigation study. Not used in assessment.
45535401	Teixeira, D. (2000) RPA 202248--Determination of Effects on Vegetative Vigor Screening of Three Plant Species Sprayed at Low Volume: Final Report: Lab Project Number: 10566.0498.6491.610: 98-6-7376. Unpublished study prepared by Springborn Laboratories, Inc. 68 p.	Used in effects characterization. Only 3 rates were tested. Test material was TGAI degradate. Lettuce data were invalid.
45535402	Teixeira, D. (2000) RPA 201772--Determination of Effects on Vegetative Vigor Screening of Three Plant Species Sprayed at Low Volume: Final Report: Lab Project Number: B002879: 98-6-7368: 10566.0498.6489.610. Unpublished study prepared by Springborn Laboratories, Inc. 66 p.	Not used in assessment. Screening level data (3 test concentrations) for cabbage, lettuce and turnip. More refined endpoints available.
45535403	Hoberg, J. (2001) **Supplement Report** to RPA 201772--Determination of Effects on Seed Germination, Seedling Emergence and Vegetative Vigor of Ten Plant Species: Lab Project Number: 94-4-5234: 10566.0194.6326.610: 011056. Unpublished study prepared by Springborn Laboratories, Inc. 137 p.	Not used in effects characterization. Classified invalid due to differences in data and original submission.
45535404	Teixeira, D. (1998) RPA 201772--Determination of Effects on Vegetative Vigor of Three Plant Species: Final Report: Lab Project Number: B003489: 98-6-7370: 10566.0498.6490.610. Unpublished study prepared by Springborn Laboratories, Inc. 65 p.	Not used in assessment. Screening level data (3 test concentrations) for cabbage, lettuce and turnip. More refined endpoints available.
45535405	Teixeira, D. (1998) RPA 202248--Determination of Effects on Vegetative Vigor of Three Plant Species: Final Report: Lab Project Number: B003490: 98-7-7385: 10566.0498.6492.610. Unpublished study prepared by Springborn Laboratories, Inc. 67 p.	Used in effects characterization. Only 3 rates were tested. Test material was TGAI degradate.

MRID	Citation Reference	Comments
45658802	Christ, M.; Abedi, J. (2002) Effect on Vegetative Vigor of Non-Target Terrestrial Plants (Tier II) Isoxaflutole (Balance) Wettable Granule 75% w/w: Lab Project Number: 01Y732741: B003805. Unpublished study prepared by Aventis CropScience, USA. 125 p.	Data included in effects characterization. Test material was Balance.
47114002	Pallett, K.; Nguyen, D.; Gosch, H. (2006) BYH 18636 + AE 0001789 + IFT SC 465: Effects on Eleven Species of Non-Target Terrestrial Plants: Vegetative Vigour Test (Tier 2). Project Number: VV/05/064, EBGSP025. Unpublished study prepared by Bayer Cropscience Gmbh. 211 p.	Study not used. Test material was formulated product that is not relevant to current action. Product contained safener.
47114003	Pallett, K.; Gosch, H.; Nguyen, D.; et al. (2006) BYH 18636 + (Inert Ingredient) + IFT SC 465: Effects on Eleven Species of Non-Target Terrestrial Plants: Seedling Emergence and Seedling Growth Test (Tier 2). Project Number: SE/05/063, EBGSP026. Unpublished study prepared by Bayer Cropscience Gmbh. 281 p.	Study not used. Test material was formulated product that is not relevant to current action. Product contained safener.
47114006	Bach, F.; Pallett, K. (2006) Higher Tier Non Target Terrestrial Plant Study on the Vegetative Vigour Test of 3 Plant Species Determined Under **Semi-Field Conditions:** The Phytotoxic Effects of IFT + TCM + CSA SC 225 + 90 + 225 + 150 G/L. Project Number: HT06/056, EBGSP057, M/281486/01/1. Unpublished study prepared by Bayer Cropscience Gmbh. 114 p.	Study not used. Test material was formulated product that is not relevant to current action. Product contained safener.
47114013	Bach, F.; Pallett, K. (2007) Higher Tier Non Target Terrestrial Plant Study on the Seedling Emergence and Growth of 3 Plant Species Under Semi-Field Conditions: The Phytotoxic Effects of BYH 18636 + Isoxaflutole +(Inert Ingredient) SC 90 + 225 + 150 (TCM+IFT+CSA SC 90 + 225 + 150 G). Project Number: HT06/055, EBGSP083. Unpublished study prepared by Bayer Cropscience Gmbh. 137 p.	Study not used. Test material was formulated product that is not relevant to current action. Product contained safener.
47114032	Gosch, H.; Bach, F.; Nguyen, D. (2007) Isoxaflutole + Cyprosulfamide SC 240 + 240 g/L Effects on Eleven Species of Non-Target Terrestrial Plants: Seedling Emergence and Seedling Growth Test (Tier 2). Project Number: SE/06/033, EBUBP062, M/283723/01/1. Unpublished study prepared by Bayer Ag, Institute of Product Info. & Residue Anal. 247 p.	Study not used. Test material was formulated product that is not relevant to current action. Product contained safener.
47114033	Sowig, P.; Gosch, H.; Bach, F.; et al. (2007) Isoxaflutole & Cyprosulfamide SC 240 + 240 g/L Effects on Eleven Species of Non-Target Terrestrial Plants: Vegetative Vigour Test (Tier 2). Project Number: VV/06/034, EBUBP061, M/283816/01/1. Unpublished study prepared by Bayer Ag, Institute of Product Info. & Residue Anal. 234 p.	Study not used. Test material was formulated product that is not relevant to current action. Product contained safener.

Attachment 2. Species Sensitivity Distributions for Plants exposed to Isoxaflutole

Species sensitivity distributions were developed in order to consider the range of sensitivities of plants to isoxaflutole among the tested species. These distributions were also used to characterize differences in toxicity of TGAI isoxaflutole and Balance. This attachment describes the methods used to derive SSDs and the results.

Methods

In order to develop distributions displaying differences in sensitivities among test species, sources of variability and bias were eliminated when possible. To that end, distributions were composed of the same toxicity endpoints (*i.e.,* EC_{25} values expressed in units of lb a.i./A) which were obtained from standard vegetative vigor and seedling emergence studies. In addition, separate distributions were developed for each type of effect. For vegetative vigor (VV), distributions were developed for shoot height (also referred to as length), shoot weight and root weight (**Table 3**). For seedling emergence (SE), a distribution was developed for shoot weight (**Table 4**). In cases where multiple EC_{25} values were available for the same test species, the geometric mean of those values was used to derive the SSD. Non-definitive EC_{25} values (*i.e.,* values with < or >) were excluded from the SSD, as their actual value is unknown.

SSDs were developed using the SSD toolbox (version 1.0 beta[12]). Once data were imported, all available distributions (*i.e.,* normal, logistic, triangular, gumbel and burr) were fit along with 3 separate fitting methods (*i.e.,* maximum likelihood, moment estimator and graphical methods). The appropriate distribution was selected based on the highest P-value.

Distributions of toxicity data for TGAI and Balance were compared to determine potential influences of test material on toxicity results. In cases where the 95% confidence interval around the SSD for Balance toxicity data overlapped primarily with the 95% confidence interval for the SSD for TGAI toxicity data, it was assumed that the test material did not influence species responses. In those cases, SSDs were developed from data conducted with both Balance and TGAI. When the 95% confidence intervals only partially overlapped and the central estimates of the SSD for Balance was primarily outside of the 95% confidence interval for the TGAI SSD, it was assumed that the test material did influence the toxicity results. In that case, the SSD was derived using Balance toxicity data (because it is most relevant to the action).

Results and Discussion

Comparisons in toxicity of Balance and TGAI

When considering potential differences in toxicity of TGAI and Balance, three different data sets were used, including: VV height, VV shoot weight and SE height. For VV shoot weight and SE height, the best fit distribution was triangular (fitting method is maximum likelihood). For VV height, the best fit distribution was burr for Balance and Triangular for TGAI. **Table 2-1**

[12] Available online at: https://www.epa.gov/endangered-species/provisional-models-endangered-species-pesticide-assessments

includes a summary of the distributions used for each data set, P-values and Akaike Information Criterion (AICc) weights.

Table 2-1. Distributions used for each SSD generated to compare toxicity of Balance and TGAI.

Study Type	Endpoint	Test material	Number of species	Distribution shape*	P-Value	AICc weight
Vegetative vigor	shoot weight	Balance	17	triangular	0.9930	0.4723
		TGAI	10	triangular	>0.9999	0.3876
	shoot length	Balance	16	burr	0.9590	0.7187
		TGAI	9	triangular	>0.9999	0.2820
Seedling emergence	shoot length	Balance	10	triangular	>0.9999	0.4069
		TGAI	9	triangular	0.9990	0.4045

*Fitting method is maximum likelihood.

For both VV data sets, the central distribution estimates are similar, with substantial overlap in the 95% confidence intervals for the Balance and TGAI SSDs. Therefore, there is no apparent difference in effects to VV attributed to Balance and TGAI (**Figures 2-1 and 2-2**). For the VV SSDs used in this risk assessment, available toxicity data for Balance and TGAI will be combined.

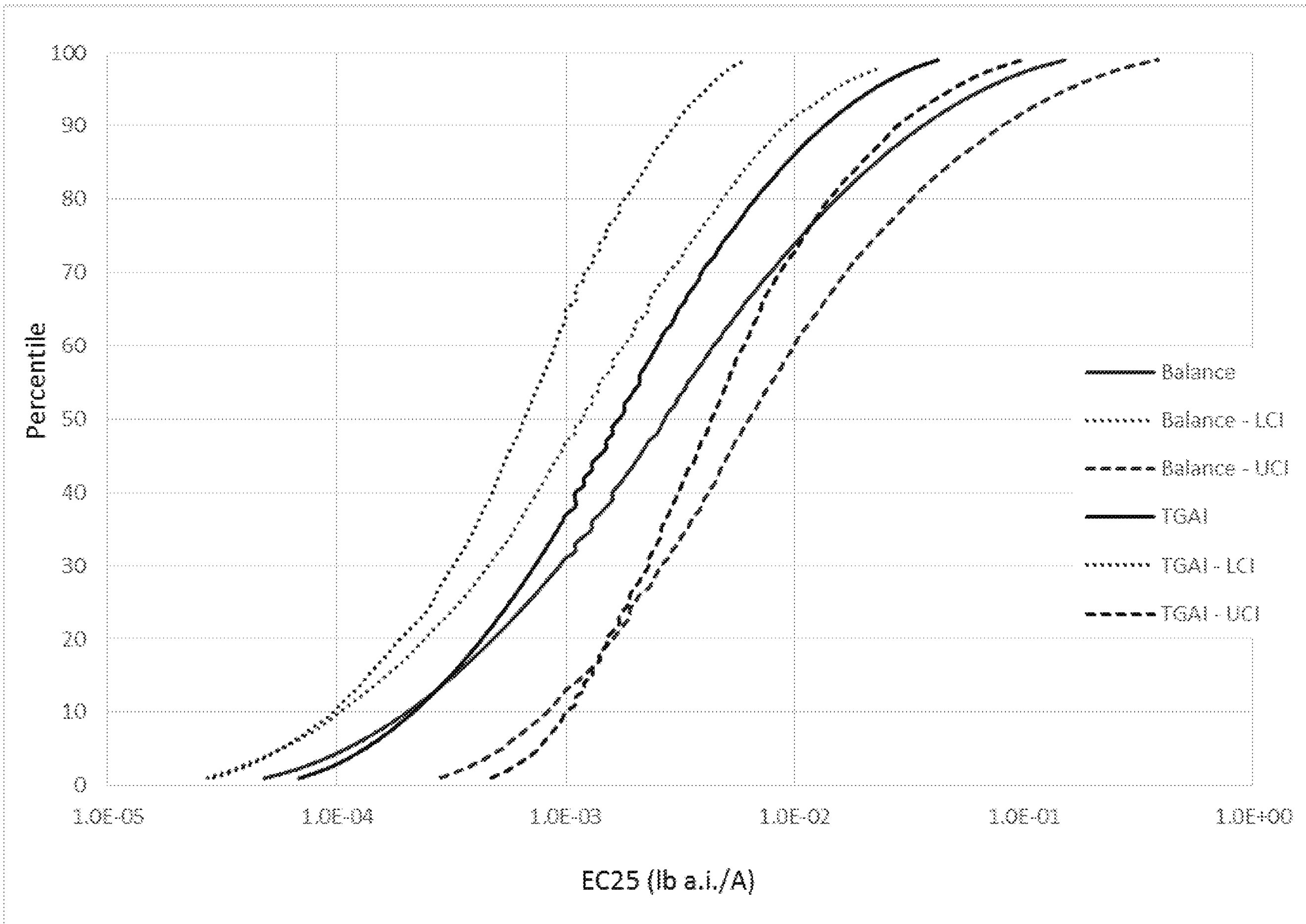

Figure 2-1. SSDs for <u>vegetative vigor</u> EC_{25} values for <u>shoot weight</u>. Solid lines depict best estimates of SSDs for Balance (red) and TGAI isoxaflutole (black). Dotted lines represent 95th percent confidence intervals. Both distributions are triangular. (LCI = lower confidence interval; UCI = upper confidence interval)

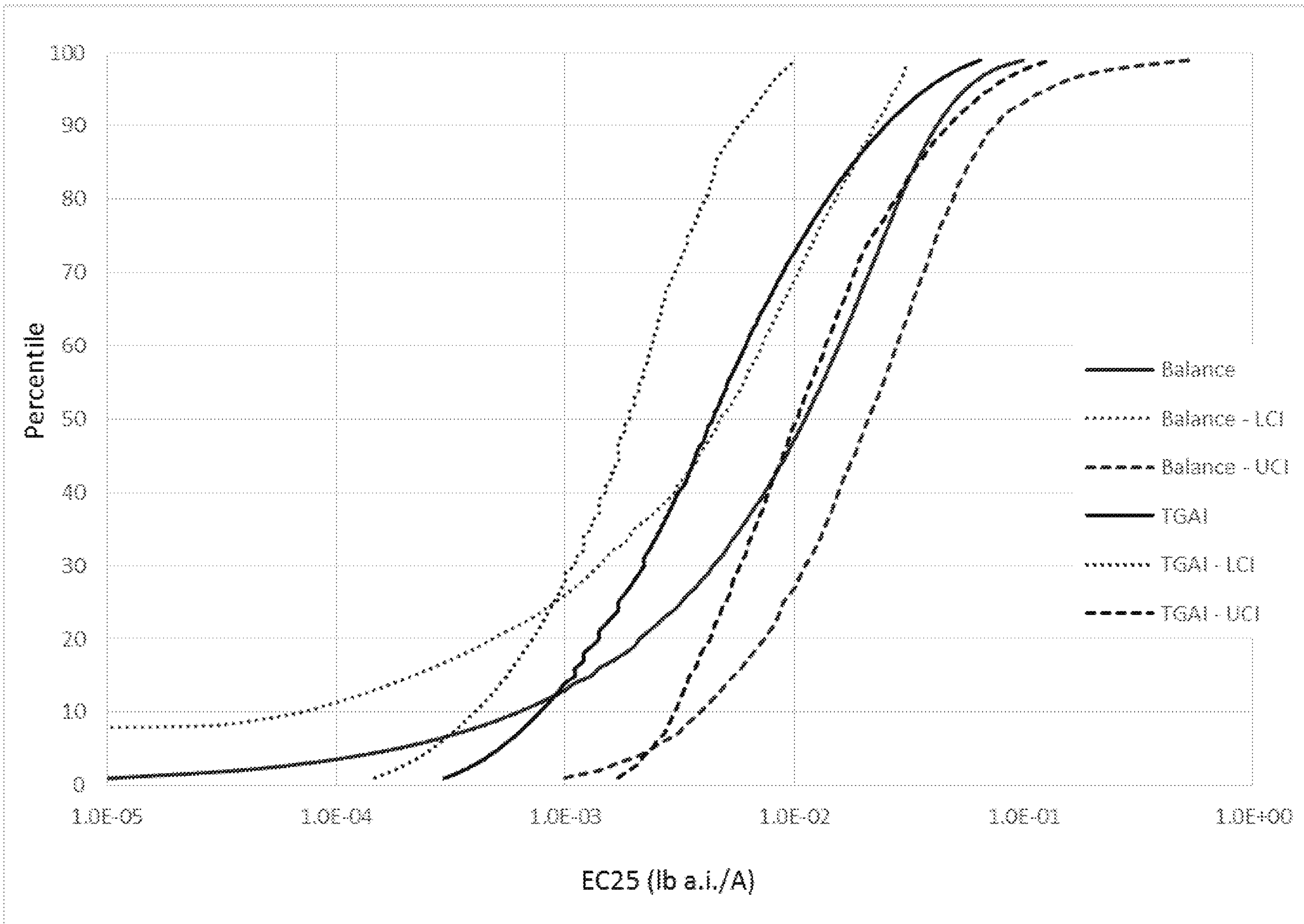

Figure 2-2. SSDs for vegetative vigor EC_{25} values for shoot height. Solid lines depict best estimates of SSDs for Balance (red) and TGAI isoxaflutole (black). Dotted lines represent 95th percent confidence intervals. Balance distribution is Burr and TGAI is triangular. (LCI = lower confidence interval; UCI = upper confidence interval)

For the SE height data, the central estimates of the TGAI EC_{25} values appear to be approximately an order of magnitude more sensitive compared to the distribution for Balance. The 95% confidence intervals around the two distributions overlap somewhat; however, the central estimate of the Balance SSD is mostly outside of the confidence interval of the TGAI SSD. Therefore, there appears to be a difference in effects to SE attributed to Balance and TGAI (**Figure 2-3**).

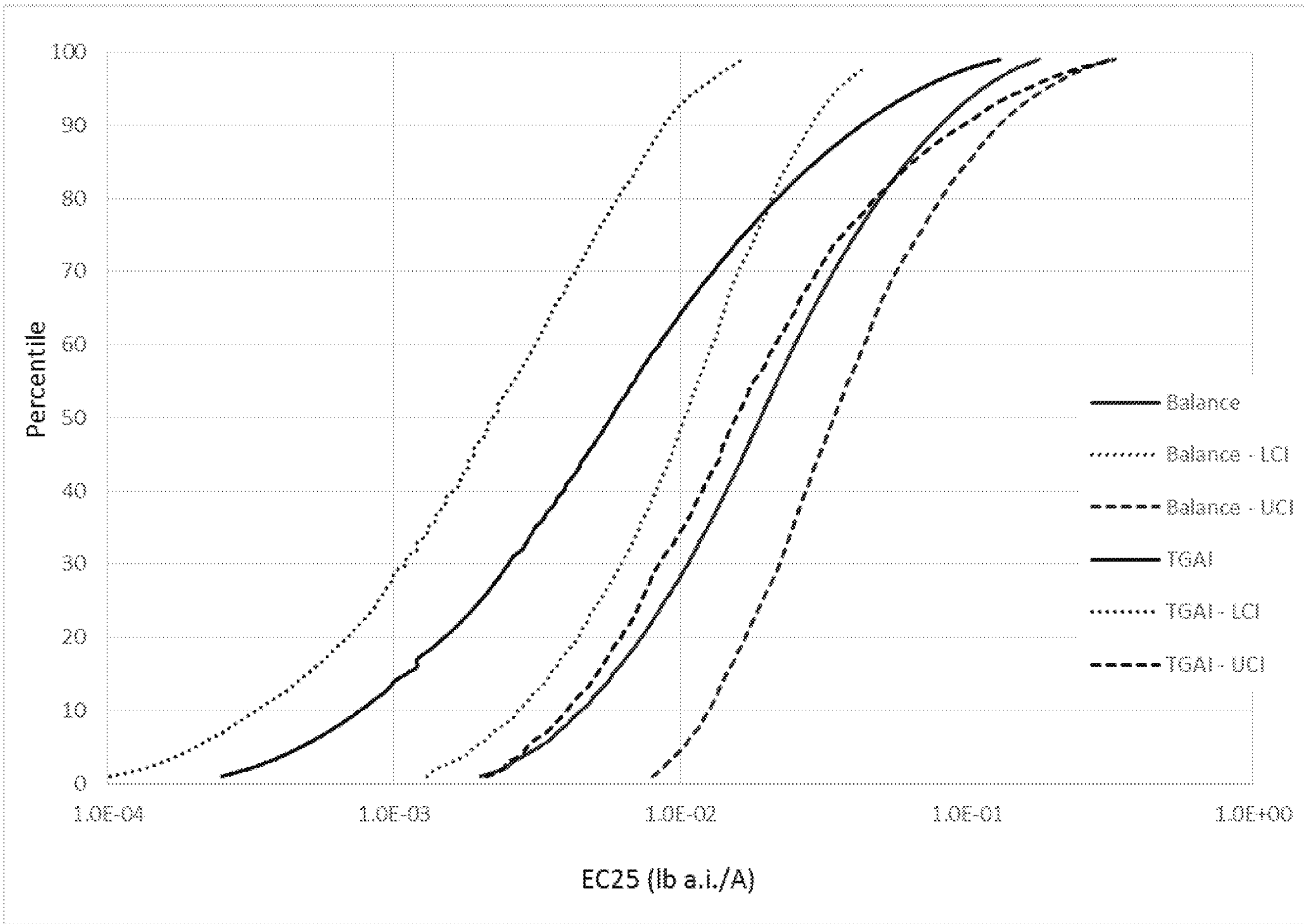

Figure 2-3. SSDs for <u>seedling emergence</u> EC_{25} values for <u>shoot height</u>. Solid lines depict best estimates of SSDs for Balance (red) and TGAI isoxaflutole (black). Dotted lines represent 95th percent confidence intervals. Balance distribution is Burr and TGAI is triangular. (LCI = lower confidence interval; UCI = upper confidence interval)

SSDs used for Risk Assessment

Table 2-2 includes a summary of the distributions used in this risk assessment for each endpoint. As noted above, there was no notable difference between toxicity data for balance and TGAI in vegetative vigor shoot weight and height endpoints. Therefore, these data were combined. Since the only available VV root weight data correspond to toxicity studies involving TGAI, an SSD was developed using TGAI data only. Only Balance data were used in the SE SSD because there was a difference in sensitivity in plants treated with Balance and TGAI. **Table 2-3** includes the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles of these distributions. **Figures 2-4 through 2-7** depict the VV and SE SSDs used in this risk assessment.

Table 2-2. Distributions used for SSDs generated for different endpoints.

Study	Endpoint	Test material	Number of species	Distribution shape*	P-Value	AICc weight
Vegetative vigor	Shoot weight	Balance + TGAI	17	triangular	>0.9999	0.3817
	Shoot height	Balance + TGAI	16	burr	0.9580	0.7187
	Root weight	TGAI	10	Triangular	0.9720	0.3397
Seedling emergence	Shoot height	Balance	10	triangular	>0.9999	0.4069

*Fitting method is maximum likelihood.

Table 2-3. Percentiles of SSDs used in risk assessment to characterize effects of isoxaflutole (applied as Balance) on vegetative vigor and seedling emergence to plants. Values represent EC25 values (in lb a.i./A)

Study Type	Endpoint	Percentile species from SSD						
		5	10	25	50	75	90	95
Vegetative vigor	shoot weight	1.1E-04	1.8E-04	5.3E-04	1.8E-03	6.1E-03	1.8E-02	3.1E-02
	shoot length	1.8E-04	6.2E-04	3.2E-03	1.1E-02	2.5E-02	4.2E-02	5.6E-02
	root weight	5.0E-05	1.2E-04	4.0E-04	1.9E-03	8.6E-03	3.2E-02	6.3E-02
Seedling emergence	shoot length	3.2E-03	4.5E-03	8.8E-03	1.9E-02	4.1E-02	8.0E-02	1.1E-01

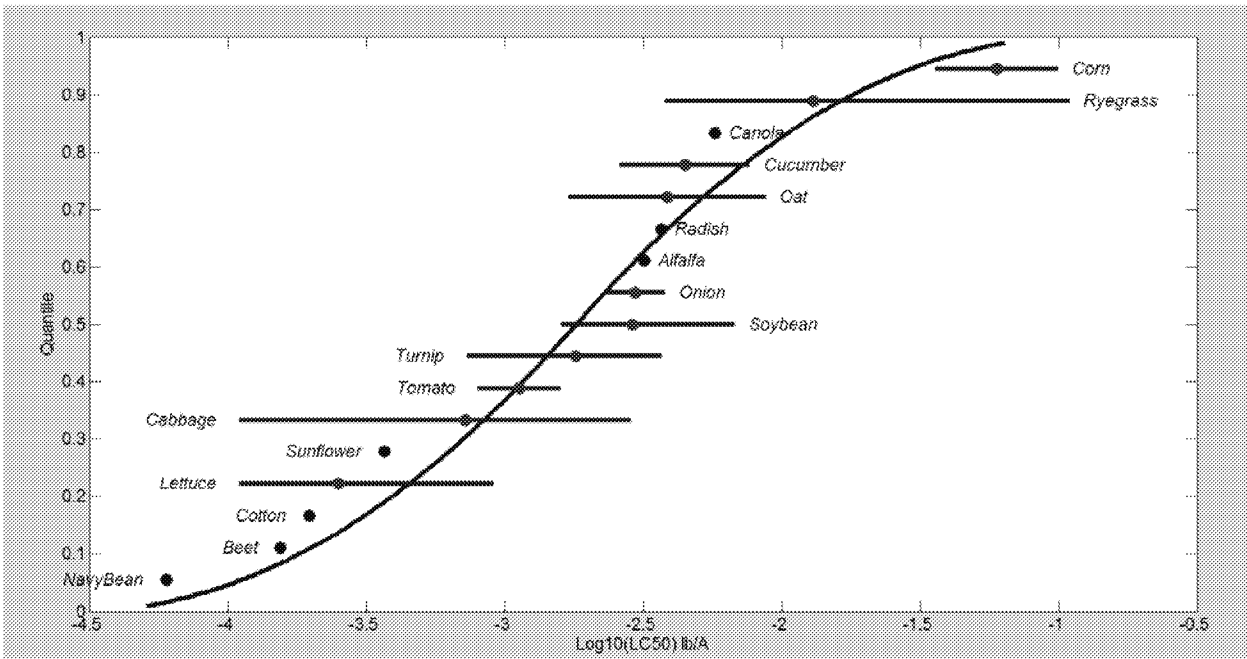

Figure 2-4. SSD for <u>vegetative vigor</u> EC_{25} values for <u>shoot weight</u> from studies involving <u>Balance and TGAI</u>. Solid lines depicts best estimates of <u>Triangular</u> SSD. Black points represent single-species EC_{25} values. Red points represent geometric means for species where multiple EC_{25} values are available (blue lines represent range).

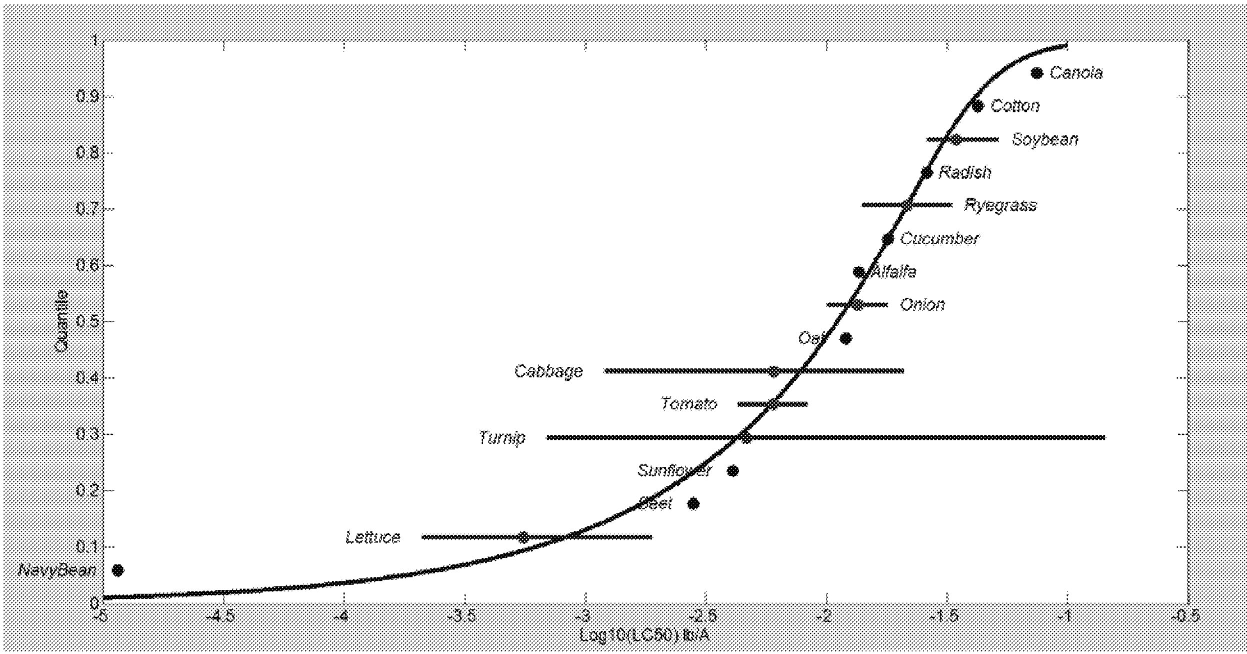

Figure 2-5. SSD for <u>vegetative vigor</u> EC_{25} values for <u>shoot height</u> from studies involving <u>Balance and TGAI.</u> Solid lines depicts best estimates of <u>Burr</u> SSD. Black points represent single-species EC_{25} values. Red points represent geometric means for species where multiple EC_{25} values are available (blue lines represent range).

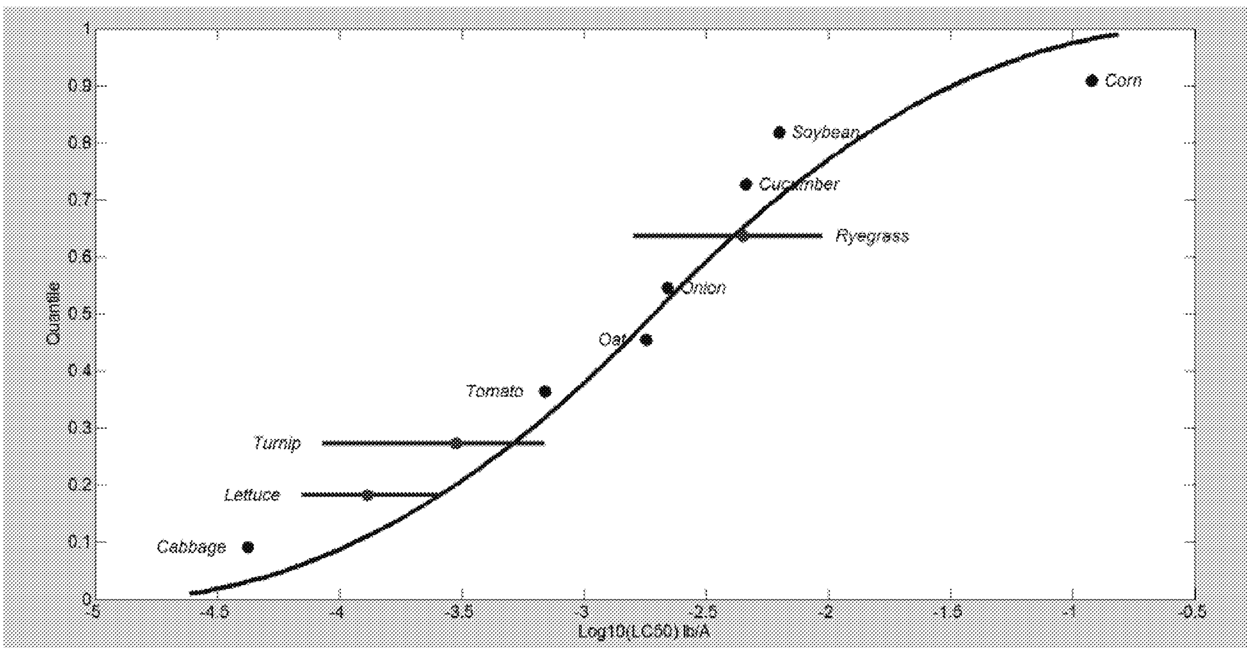

Figure 2-6. SSD for <u>vegetative vigor</u> EC_{25} values for <u>root weight</u> from studies involving <u>TGAI</u> (only). Solid lines depicts best estimates of <u>Triangular</u> SSD. Black points represent single-species EC_{25} values. Red points represent geometric means for species where multiple EC_{25} values are available (blue lines represent range).

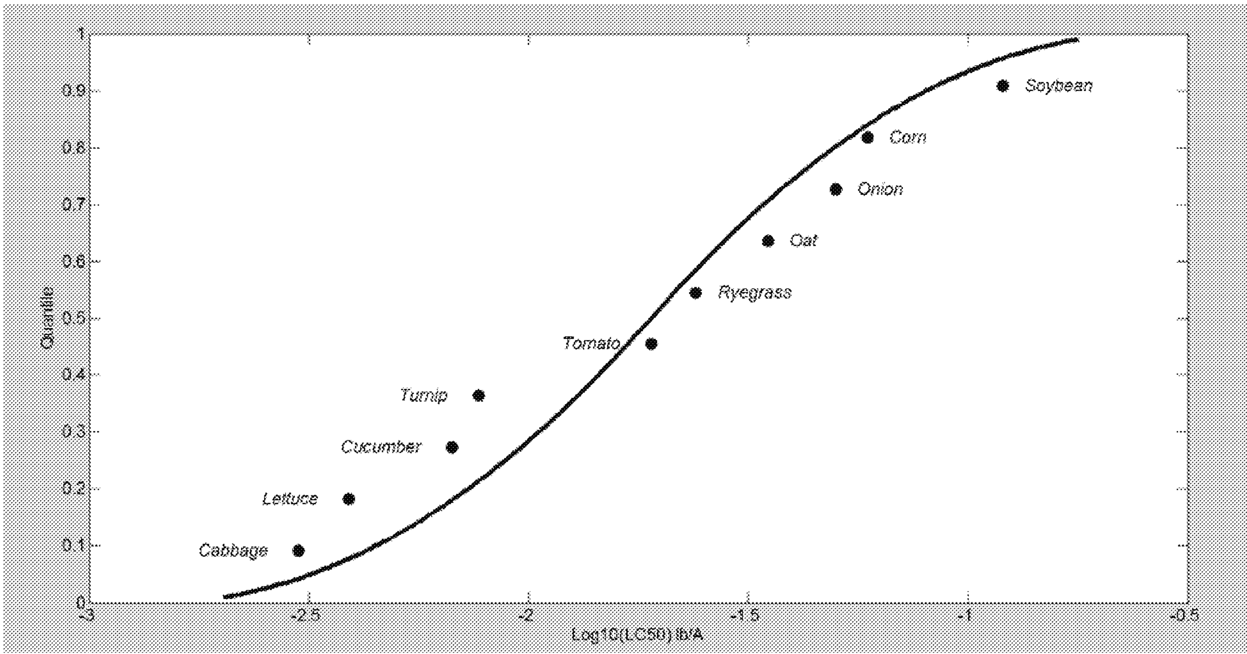

Figure 2-7. SSD for <u>seedling emergence</u> EC_{25} values for <u>shoot height</u> from studies involving <u>Balance</u> (only). Solid lines depicts best estimates of <u>Triangular</u> SSD. Black points represent single-species EC_{25} values. Red points represent geometric means for species where multiple EC_{25} values are available (blue lines represent range).

Attachment 3. Summary Table of Isoxaflutole Incidents Associated with Non-direct Plant Application.

The table below includes a summary of isoxaflutole incidents related to carryover, drift, runoff and other non-direct plant applications from the EIIS Database (queried Feb. 25, 2015, 1999 through present).

Incident Number	Species	Route of Exposure	Distance from Edge of Field	Magnitude	Appli-cation Rate	Legality	Year	Summary Text
I010653-018	Alfalfa	Carryover	On site	32 Acres	N/R	Registered Use	2000	Complaint from Powell, WY, that Balance WDG herbicide damaged 32 acres of alfalfa. The pesticide had been applied the year before to corn and there was a carryover to the current crop of alfalfa.
I010563-041	Bean	Carryover	On site	All 120 Acres	1.5 oz/A	Registered Use	2000	Complaint from Edson, KS, that Balance WDG damaged all 150 acres of a dry beans crop as the result of a carryover from the year before when it was applied to corn.
I010563-042	Bean	Carryover	On site	All 30 Acres	N/R	Registered Use	2000	Complaint from Riverton, WY, that all 30 acres of a dry beans crop were damaged by Balance WDG. It had been applied the year before to corn, but the carryover to the next year damaged the dry beans crop.
I010563-043	Bean	Carryover	On site	All 15 Acres	N/R	Registered Use	2000	Complaint from Miles City, MT, that Balance WDG damaged all 15 acres of a dry beans crop. The Balance had been applied to corn the year before, but there was sufficient carryover to kill the dry beans.
I010563-045	Bean	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Hysham, MT, that Balance WDG damaged a crop of dry beans. The pesticide had been applied to corn the year before, but there was sufficient carryover to damage the dry beans.
I010563-046	Bean	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Worland, WY, that Balance WDG damaged a crop of dry beans. The pesticide had been applied the year before to corn, but there was sufficient carryover to damage the dry beans.
I010563-047	Bean	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Glendive, MT, that Balance WDG damaged a crop of dry beans. The pesticide had been applied to corn the year before, but there had been sufficient carryover to damage the dry beans.
I010653-017	Bean	Carryover	On site	Unknown	N/R	Registered Use	2000	Complaint from Bathgate, ND, that Balance WDG herbicide damaged a crop of dry beans. The pesticide had been applied the year before, to corn, but there was a carryover to the next year when it adversely affected the dry beans.
I013103-017	Corn	Soil transport	N/R	48 of 100 acres	1.88 oz/acre	Registered Use	2002	Complaint from Onslow, IA, that Aventis damaged 48 acres of a 100-acre crop of field corn. No mention was made in the report of the type of damage inflicted. This is a P-A severity type of incident.
I010985-004	Corn	N/R	N/R	N/R	N/R	Registered Use	2000	Complaint from Ulysses, KS, that Balance WDG had damaged 100 acres of corn, out of a total of 125 treated. This is a P-A level plant injury.
I013092-004	Corn, field	Drinking	N/R	20,000 plants/acre	14 oz/acre	Registered Use	2002	Complaint from Charles City, IA, that EPIC DF Herbicide damaged 10,000 to 20,000 field corn plants per acre. The total area was not mentioned but this was considered a P-A severity category. The explanation given by Bayer was "Cold wet weather caused the above result. The corn was not able to grow due to poor growing conditions.

Incident Number	Species	Route of Exposure	Distance from Edge of Field	Magnitude	Appli-cation Rate	Legality	Year	Summary Text
I010472-070	Lentil	Carryover	On site	20 Acres out of 40	1 oz/A	Registered Use	2000	Complaint from Riverton, WY, that Balance WDG damaged 20 acres out of 40 acres of dry beans. The pesticide had been applied to a corn crop the year before but there was a carryover that damaged the beans. Part of the information here was taken from I010507-010. This is a P-A level plant injury.
I010563-044	Soybean	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Waynetown, IN, that Balance WDG damaged a crop of soybeans. The pesticide had been applied to corn the year before, but there was enough carryover to kill the soybeans. No details were given in the report but, for the sake of completeness, the incident is reported here.
I010653-016	Soybean	Carryover	On site	Unknown	N/R	Registered Use	2000	Complaint from Sloan, IA, that Balance WDG herbicide damaged a crop of soybeans as the result of a carryover from the previous year when it was applied to corn.
I010472-038	Sugar beet	Carryover	On site	100 Acres of 135	N/R	Registered Use	2000	Complaint from Worland, WY, that Balance WDG had damaged 100 acres of a 135 acre crop of sugar beets. The information contained in I010472-038 was modified to include that presented in I010507-001. There had been a treatment of a corn plot with Balance WDG in 1999, and when sugar beets were planted in 2000 there was enough Balance in the soil to damage the sugar beets. This is a P-A level plant injury.
I010472-041	Sugar beet	Carryover	On site	All 16 Acres	1 oz/A	Registered Use	2000	Complaint from Worland, WY, that Balance WDG damaged all 16 acres of sugar beets. This was a carryover effect from the year before when Balance WDG had been used on a corn field. The data in this report include data that was given in I010507-002. This is a P-A level plant injury. It was logged in the EIIS database as a direct treatment, rather than carryover.
I010472-042	Sugar beet	Carryover	On site	70 Acres out of 84	N/R	Registered Use	2000	Complaint from Basin, WY, that Balance WDG had damaged 70 acres of an 84 acre plot of sugar beets. In 1999 Balance WDG had been added to a field that was to be planted in corn, and there was sufficient carryover in the soil to damage the sugar beets planted in 2000. This incident report (I0100472-042) includes data contained in I010507-003. The crop damage was a P-A level type.
I010472-054	Sugar beet	Carryover	On site	10 Acres	N/R	Registered Use	2000	Complaint from Riverton, WY, that Balance WDG damaged 10 acres of sugar beets. In the previous year, 1999, the field had been treated with this pesticide for a planting of corn, and there was a carryover effect on the sugar beets in 2000. There had been 30 acres planted, of which 10 acres were damaged. In the initial mailing from Aventis, these numbers were reversed; contrary to the heading of the summary sheet, therefore, this is not a P-A level plant injury.
I010472-055	Sugar beet	Carryover	On site	All 46 Acres	N/R	Registered Use	2000	Complaint from Joliet, MT, that Balance WDG damaged all 46 acres of a sugar beets crop. In 1999 this pesticide was added to a field in which corn was to be planted, and there was a carryover effect that killed the sugar beets in 2000. This is a P-A level type plant injury.
I010472-068	Sugar beet	Carryover	On site	All 45 Acres	1 oz/A	Registered Use	2000	Complaint from Arapahoe, WY, that Balance WDG had damaged all 45 acres of a crop of sugar beets. The pesticide had been applied to a corn field the year before, and there was a carryover that killed the sugar beets. This is a P-A level plant injury. Pertinent parts of this summary were taken from I010507-008.
I010472-069	Sugar beet	Carryover	On site	100 Acres of 200	1 oz/A	Registered Use	2000	Complaint from Worland, WY, that 100 acres of a 200-acre crop of sugar beets was damaged by Balance WDG which had been applied to the field the year before (a

Incident Number	Species	Route of Exposure	Distance from Edge of Field	Magnitude	Application Rate	Legality	Year	Summary Text
								carryover effect). Some of the material in this report was taken from I010507-009. This is a P-A level plant injury.
I010472-075	Sugar beet	Carryover	On site	All 110 Acres	N/R	Registered Use	2000	Complaint from Fairview, MT, that Balance WDG damaged all 110 acres of a crop of sugar beets. Balance WDH had been applied to the field in question the year before, when it was planted to corn, but there was a carryover that killed the sugar beets. This is a P-A level plant injury. Part of the information contained here was taken from I010507-011.
I010472-076	Sugar beet	Carryover	On site	All 36 Acres	N/R	Registered Use	2000	Complaint from Worland, WY, that Balance WDG damaged all 36 acres of a crop of sugar beets. The pesticide had been applied the year before, to corn, and there was a carryover that caused the damage to the sugar beets. Part of the information of this report came from I010507-012. This is a P-A level plant injury.
I010472-077	Sugar beet	Carryover	On site	All 26 Acres	N/R	Registered Use	2000	Complaint from Worland, WY, that Balance WDG damaged all 26 acres of a crop of sugar beets. The pesticide had been applied the previous year in that field, planted to corn, and there was a carryover that killed the sugar beets. Part of the information for this report came from I010507-013. This is a P-A level plant injury.
I010563-048	Sugar beet	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Terry, MT, that Balance WDG damaged a crop of sugar beets. The pesticide had been used the year before on corn, but there was sufficient carryover to damage the sugar beets.
I010563-049	Sugar beet	Carryover	On site	Unknown	N/R	Registered Use	2000	Complaint from Terry, MT, that Balance WDG damaged a crop of sugar beets. This was the consequence of a previous treatment of the field in which corn was the crop being planted. In the report there was no mention of the application rate or of the area affected.
I010563-050	Sugar Beet	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Terry, MT, that Balance WDG damaged a crop of sugar beets. The herbicide had been applied the year before to a corn crop but it carried over to the subsequent year in which sugar beets were planted. This incident is different from another reported at the same time from the same town in Montana (I010563-049) although the details are the same. No information was provided on the application rate or of the area affected.
I010563-051	Sugar Beet	Carryover	On site	N/R	N/R	Registered Use	2000	Complaint from Billings, MT, that Balance WDG damaged a crop of sugar beets. The pesticide had been applied the year before to corn and there was a carryover to the sugar beets being planted. No information was given on the application rate or the area affected.
I014426-005	Alfalfa	Carryover	On site	160 acres	N/R	Registered Use	2003	The farmer alleges an application to his corn crop in the spring of 2002 carried over to his alfalfa crop. Adverse effect was leaf loss. Bayer denies this effect.
I014426-009	Alfalfa	Carryover	On site	160 acres	N/R	Registered Use	2003	Farmer claims that carryover caused plant damage to the alfalfa crop. The product, EPIC (Flufenacet + Isoxaflutole), was applied on corn the year before. Bayer denies this effect.
I024295-038	Corn	N/R	N/R	100% of 256 acres	N/R	Registered Use	2012	On June 22, 2012 in Jackson County, MO 100% of 256 acres of corn was experienced leaning and stand reduction after an application of the products Capreno (a.i. thiencarbazone-methyl, isoxaflutole) and Round-up Non-specific (a.i. glyphosate). Alleged phytotoxic reaction to product following application to corn

Incident Number	Species	Route of Exposure	Distance from Edge of Field	Magnitude	Appli-cation Rate	Legality	Year	Summary Text
								crop. The Registrant suggested the probable causes were improper planting depth and low moisture.
I016407-052	Corn, field	Carryover	N/R	53% of 40 acres	N/R	Registered Use	2005	Incident in Havelock, IA, in which Balance Pro was believed to have been responsible for damage done to 53% of a 40-acre crop of field corn. The symptoms were whitening at 3-leaf or later, and stunting. Bayer attributed the damage to an instance of carryover of FirstRate. No mention was made of the crop to which FirstRate had been applied, nor to its time of application.
I024202-019	Corn	Compost	On site	100% of 80 Acres	N/R	Undeter-mined	2012	On May 19, 2012 in Butler County, IA 100% of 80 acres of corn exhibited stand reduction after an application of the products Corvus (a.i. thiencarbazone-methyl, isoxaflutole) and Atrazine Non-Specific (a.i. atrazine). The Registrant suggested that the stand reduction may be due to a late application and/or the adjuvant contained in mix.
I016407-046	Corn, field	N/R	N/R	552 acres	N/R	Misuse	2005	Incident in Stromsburg, NE, in which Balance Pro is said to have damaged 552 acres of field corn. The symptoms were whitening at 3-leaf or later, and stand reduction. Bayer attributed the damage to an excess use of the product. A total of 3.6 oz had been applied.
I024431-045	Corn	Drift, spray	Vicinity	75% of 240 acres	N/R	Misuse (accidental)	2012	On May 16, 2012 Holt County, MO 75% of 240 acres of corn displayed the adverse effect lodging after an application of the products Corvus (a.i. thiencarbazone-methyl, isoxaflutole) and Touchdown (a.i. glyphosate). Miscommunication between the grower and retailer as to when to spray. A settlement was reached between the grower and retailer. The Registrant states the probable cause late application.
I027332-007	Fruit Tree	Drift, spray	N/R		N/R	Misuse	2015	Corvus Herbicide (a.i. isoxaflutole) was allegedly applied during 25-30 mph winds toward property causing concern for drift to fruit trees and bees. No adverse effects were noted at the time of the call.
I023644-015	Corn	N/R	N/R	100% of 44.3 acres	N/R	Undeter-mined	2011	On May 25, 2011 in Washoe County, NV 100% of 44.3 acres of stacked corn exhibited whitening at emergence after an application of the products Balance Pro (a.i. isoxaflutole) and Atrazine Non-specific (a.i. atrazine). The Registrant suggested application error and application overlap may have been the probable causes.
I024431-040	Corn	N/R	N/R	100% of 40 acres	N/R	Undeter-mined	2012	On June 22, 2012 in Lamb County TX 100% of 40 acres of corn was exhibited yellowing and whiting at 3 leaf or later after an application of the products Balance Flexx (a.i. isoxaflutole) and Atrazine Non-specific (a.i. atrazine). Alleged phytotoxic reaction to product following application to corn crop. The Registrant suggested the probable cause was excess moisture. Re-plant is required.

N/R = Not Reported or not clear from report. P-A = Alleged effect occurred on more than 45 percent of the acreage exposed to the pesticide.

Attachment 4. Audrey III Equation Documentation

1) The PRZM time series output file ('ZTS) contains the storm related inputs used in Audrey III. As it is currently formatted, a daily value is put out for each parameter in cumulative mode. That is, output is a cumulative running total for that variable. The parameters of interest for calculating the runoff depth where the units are cm for each event:
   a. $D_i = RUNF_i$
   b. $RM_i = RFLX_i$
   c. $RE_i = EFLX_i$
   d. $W_i = PRCP_i$

   where D is the depth of runoff for the event in centimeters, equivalent to the RUNF in the PRZM zts file, RM_i is the mass of pesticide for runoff on day I in $kg \cdot ha^{-1}$, and is the RFLX in the PRZM zts file, RE is the mass of pesticide on eroded sediment on day, in $kg \cdot ha^{-1}$, and is the EFLX variable in the zts file, and W_i is the depth of precipitation in cm on day i, and is the PRCP in the PRZM output. RUNF, RFLX, EFLX, and PRCP are PRZM output parameters in the time series output file.

   GEOMETRY OF THE PESTICIDE EXPOSURE ZONE

2) The area of the plant exposure zone (PEZ) is determined by the length of the side of the field and width of the zone where overland flow is maintained. For example for a square 10 ha field, the length of the side of field, L_{PEZ}:
   a. $L_{PEZ} = \sqrt{10ha\left(\frac{10000\ m^2}{ha}\right)} = \sqrt{100000\ m^2} = 316.2\ m$
3) Overland flow can be maintained for 50 to 300 feet before a concentrated flow regime set in. Once concentrated flow moves the water relatively rapidly through rill or gulleys, it presents little opportunity for exposure for terrestrial plants. For the purposes of this example, we will assume 50 feet = 15.2 m Therefore, the area of the Plant Exposure Zone (PEZ) in square meters is equivalent to the zone at the edge of the field where overland flow is maintained:
   a. $A_{PEZ} = L_{PEZ}\, xW_{PEZ} = 316.2mx15.2m = 4819m^2$
   b.
4) For the purpose of this assessment, the VW_{PEZ} will partition into three portions, one part continues to runoff past the edge of the PEZ as concentrated flow and enters stream, pond or other water body, the second part infiltrates beyond the bottom of the Plant Exposure Volume in the PEZ, and the third part is retained in the PEV. This third part is the portion that results in exposure to terrestrial plants. The total volume of the PEV is the area of the PEV times the depth of soil in the PEV, D_{PEV}. Since the majority of water taken up by plants is from the top 6 inches of soil, the D_{PEV} is assumed to be 6 in ≈ 15 cm=0.15m.
   a. $V_{PEZ} = A_{PEZ}xD_{PEV} = 4819m^2x0.15m = 722.8m^3$

HYDROLOGY

1) To get the total mass of pesticide and water coming onto the PEZ, we need to account for the areas of the treated field (for the volume of runoff water, mass of pesticide in runoff and pmass of pesticide on eroded sediment:
    a. $R_i = D_i * A_{field}$
    b. $P_i = W_i * A_{PEZ}$

where

R_i	=	runoff flow from treated field (PRZM time series file) (m^3)
P_i	=	precipitation onto PEZ (PRZM time series file) (m^3)

2) The total volume in the PEZ can also be expressed as :
    a. $V_{PEZ} = V_{soil} + V_{water}$
    b. $\theta = \frac{V_{water}}{V_{PEZ}}$
    c. $V_{water} = \theta V_{PEZ}$
3) The flow balance in the PEZ is:
    a. $R_i + P_i = I_i + Q_i + \theta_i V_{PEZ}$

where

I_i	=	leaching from PEZ below the root extraction zone (m^3)
Q_i	=	runoff flow from PEZ (m^3)
θ_i	=	volumetric water content of soil (m^3/m^3)
V_{PEZ}	=	volume of PEZ (m^3)

As water will always be in the PEZ, θ should always be at or above THEWP, or the wilting point (m^3/m^3). θ should always be at or below THEFC, or the field capacity (m^3/m^3). When runoff and precipitation enter the mixing cell, the amount of water entering (R+P) plus the amount present from the previous day is compared to the THEFC. If it is greater, than θ is set to THEFC and the remainder is evaluated for runoff from the PEZ (Q) and leaching from the PEZ (I). If R and P are 0, and the amount from the previous day is greater than the wilting point, θ is set to THEWP and the water leaves the PEZ as leachate (I).

If Θ is set to THEFC and additional water is available for runoff, Q is calculated using the following algorithm

4) To get the volume of each runoff event in liters R_i, multiply the storm depth by the area of the field (10 hectares) and convert the units:

   a. $R_i = \left(\frac{D_i\, cm}{1}\right)\left(\frac{1m}{100\, cm}\right)\left(\frac{10\, ha}{1}\right)\left(\frac{10000\, m^2}{ha}\right)\left(\frac{1000\, L}{1\, m^3}\right) = 10^6 D_i$

5) The total volume of water in liters for each rainfall event that enters the PEZ in the volume of runoff from the field plus the precipitation that falls directly on the PEZ. This volume is:

   a. $VP_{(i)} = P_i\left(\frac{1\, m}{100cm}\right)A_{PEZ}$

   The water capacity of the PEV, WC_{PEV}, is the available water capacity of the soil multiplied volume of the PEV. The available water capacity of the soil is the difference between field capacity and the wilting point water capacity of the soil. These two parameters are PRZM inputs THEFC[13] and THEWP, respectively. The available water capacity varies from soil to soil, but can be calculated for each scenario by looking up THEFC and THEWP in the PRZM input file. Units for THEFC and THEWP and V_{water}/V_{soil}.

   b. $AWC = THEFC - THEWP$

6) For the Kansas sorghum scenario used in this example has a Dennis silt loam soil where THEFC = 0.247 and THEWP = 0.097, the WC_{PEZ} is:

   a. $WC_{PEZ} = V_{PEZ} x AWC = 722.8m^3 x(0.247 - 0.097) = 108.1m^3$

7) For each rainfall event, a portion of the runoff will infiltrate into the soil in the PEZ. The amount that infiltrates is dependent on the curve number, the curve number associated with each scenario can be associated with the Hydrologic Group of the soil, which are a labeled A through D. The Dennis silt loam soil is Hydrologic Group C and the curve number used for during the cropping season is 86. Note that the equation was developed with depth in inches, so TD_i must be converted for the calculation. The curve number equation is:

   a. $Q = 2.54\frac{\left(\frac{TD_i}{2.54}-0.2S\right)^2}{\left(\frac{TD_i}{2.54}+0.8S\right)}$, where

   b. $S = \frac{1000}{CN} - 10$

   c. Where Q is the runoff depth from the PEZ. Note that if the depth in inches is less than 0.2S, than the numerator in equation 10a is negative. This implies that all the water is absorbed on the PEZ and nothing runs off. Q is set to zero when this occurs.

   d. If the term in parentheses in the numerator in 10a is a negative number, it means that the runoff event is less than the capacity of the soil to absorb it and the runoff of the PEZ will be zero, so

[13] THEFC stands for theta at field capacity, THEWP stands for theta at the wilting point. Theta (θ) is the symbol used for volumetric soil water content by soil scientists.

e. $if\ \left(\frac{TD_i}{2.54} > 0.2S\right) then\ Q = 2.54\frac{\left(\frac{TD_i}{2.54}-0.2S\right)^2}{\left(\frac{TD_i}{2.54}+0.8S\right)}, else\ Q = 0$

f. I is then calculated by I = R + P - Q - ΘVp

PESTICIDE LOADINGS to the PEZ

Pesticides can be loaded onto the PEZ from three sources, spray drift, dissolved in runoff coming from the adjacent treated field, and adsorbed onto eroded sediment coming from the adjacent treated field. Spray drift deposition curves for 9 different application methods were estimated using AgDrift version 2.1.1. Those 9 methods are in **Table 4-1**.

Table 4-1. Spray drift application methods simulated in Audrey III

Method	Use
aerial, very fine to fine spray	ultralow volume applications (ULV)
aerial, fine to medium spray	default aerial spray
aerial, medium to coarse spray	mitigation, spray quality restricted on label
aerial, coarse to very coarse spray	mitigation, spray quality restricted on label
air blast, normal orchard	most orchards and vineyard applications
air blast, sparse orchard	dormant sprays, young/non-bearing orchards, tall orchards (pecans)
ground spray – high boom	default ground spray
ground spray – low boom	pre- emergent sprays, mitigation practice

Spray deposition can be calculated in three ways, the application rate is assumed for deposition on the PEZ at the field edge. The point deposition at the far edge of the PEZ can be interpolated from the appropriate deposition curve, depending on the application type. The mean deposition across the PEZ is calculated by numerically integrating the deposition curve across the PEZ width using the trapezoidal rule.

8) The mass of pesticide in runoff for the whole PEZ is mass of pesticide in runoff in kg·ha^{-1} from the treated field, RM_i, (equation 1b) times the area of the treated field, AFIELD. The area of the treated field is a PRZM input variable, and is usually set to the default value of 10 ha.
   a. $PM_i = RM_i \times AFIELD$
9) The mass of pesticide on eroded sediment for the whole PEZ is mass of pesticide on sediment in kg·ha^{-1} from the treated field, RE_i, (equation 1c) times the area of the treated field, A. The area of the treated field is a PRZM input variable, and is usually set to the default value of 10 ha.
   a. $EM_i = RE_i \times AFIELD$

Plant Exposure in the PEZ

The toxicity endpoints in the PEZ are in units of mass per unit area, kg·ha^{-1}, or lb·acre^{-1}, so the exposure estimates need to be in the same units. In order to estimate the plant EECs, we need to account for the degradation of the pesticide already in the PEZ, add mass from spray drift, erosion, and runoff loadings, and subtract the mass of pesticide lost with runout of the PEZ and leaching below the PEZ.

10) The mass entering the PEZ during storm events:
   a. Mf = Mrunoff + Merosion (PRZM time series file)
   b. Mt = Mf + Mspray drift = Mp + Me + Mo (kg)
   c. Where:
      Mf is the mass carried onto the PEZ with storm runoff
      Mrunoff is mass of pesticide dissolved in runoff form the treated field
      Merosion is the mass of pesticide adsorbed to sediment in the runoff
      Mspray drift is the mass of pesticide which drifts onto the PEZ from the treated field
      Mp is the mass of pesticide in the PEZ at the start of a time step
      Me is the mass of pesticide which is removed from the PEZ through leaching, and
      Mo is the mass of pesticide removed in runoff out of the PEZ
      In Audrey III these masses are all in kilograms

Assume that new mass MT enters as an instantaneous pulse at time zero (*i.e.,* at the beginning of each time step). Using equations 6.1, 6.2, 6.8, 6.9, and 6.16 from PRZM manual and rearranging and combining yields (similar to equation 6.20 in PRZM manual) the following mass balance description:

11) $\frac{d(C_w(\theta+K_d\rho_s))}{dt} = \frac{M_{T,0}\delta(t)}{A\Delta z} - \left(\frac{I+Q}{A\Delta z} + kK_d\rho_s + k\theta\right) C_w$
   a. Where

C_w	=	dissolved concentration in the PEZ (kg/m^3)
K_d	=	sorption coefficient (m^3/kg)
ρs	=	soil bulk density (kg/m^3)
A	=	area of PEZ (m^2)
Δz	=	depth of PEZ (m)
k	=	aerobic soil metabolism rate constant (d^{-1})

12) Assuming $\Theta + K_d\rho_s$ over the course of a day is constant,
   a. $\frac{d(C_w)}{dt} + \left(\frac{I+Q}{(\theta+K_d\rho_s)A\Delta z} + k\right) C_w = \frac{M_{T,0}\delta(t)}{(\theta+K_d\rho_s)A\Delta z}$

13) The solution of which is:

a. $C_w = \frac{M_{T,0}}{(\theta+K_d\rho_s)A\Delta z} e^{-\left(\frac{I+Q}{(\theta+K_d\rho_s)A\Delta z}+k\right)t}$

14) The quantity $(\theta + K_d\rho_s)A\Delta z$ is assumed not to change during a time step. Thus we can define the mass (M_T) in the PEZ at any point during the time step as:

a. $M_T = M_{T,0} e^{-\left(\frac{I+Q}{(\theta+K_d\rho_s)A\Delta z}+k\right)t}$

15) And in general:

a. $C_w = \frac{M_T}{(\theta+K_d\rho_s)A\Delta z}$

16) Now define:

a. $K_1 = \frac{I+Q}{(\theta+K_d\rho_s)A\Delta z} + k$ (units = d^{-1})

17) so that:

a. $M_T = M_{T,0} e^{-K_1 t}$

18) For example at the end of a time step of unit duration:

a. $M_{T,1} = M_{T,0} e^{-K_1}$

19) The average mass of pesticide in the PEZ during the course of a time step can be calculated by integration:

a. $\widetilde{M}_T = \frac{\int_{t_1}^{t_2} M_{T,0} e^{-K_1 t} dt}{t_2 - t_1}$

b. $= \left[\frac{1}{t_1 - t_2} \frac{M_{T,0}}{K_1} e^{-K_1 t_2}\right] - \left[\frac{1}{t_1 - t_2} \frac{M_{T,0}}{K_1} e^{-K_1 t_1}\right]$

20) Define $t_1 = 0$, then:

a. $\widetilde{M}_T = \left[\frac{1}{-t_2} \frac{M_{T,0}}{K_1} e^{-K_1 t_2}\right] - \left[\frac{1}{-t_2} \frac{M_{T,0}}{K_1}\right]$

b. $M_T = \left[\frac{M_{T,0}}{K_1 t_2}\right] (1 - e^{-K_1 t_2})$

21) Finally, defining t_2=1, we have:

a. $\widetilde{M}_T = \frac{M_{T,0}}{K_1} (1 - e^{-K_1})$

22) The total mass lost from the PEZ during one time step is calculated similarly:

a. $M_{T,0} - M_{T,1} = M_{T,0} - M_{T,0} e^{-K_1} = M_{T,0}(1 - e^{-K_1})$

23) The plant exposure EEC in units on each day is then:

a. $EEC_i = \frac{MM_T}{A_{PEZ}}$

Once daily EECs are calculated, the peak EEC in each year simulated is identified. The values are sorted from greatest to least and value at the 90 percentile, the 1-10 year return frequency, is selected for the point estimate of exposure.

Spray drift regression curves using IORE.
The first order decay model is :

$$1)\ \frac{dC}{dt} = -kC$$

in differential form, and

$$2)\ C = C_0 e^{-kt}$$

in integrated form, where C is the concentration, k is rate constant with units of reciprocal time, and C_O is initial concentration when t = 0. This equation commonly describes the degradation of chemicals when the rate is proportional to the concentration of the compound degrading. Empirically it is also useful to describe any process which rate of decrease is proportional to the concentration. Spray drift deposition roughly but not exactly follows this type of decrease with distance from the edge of field, *i.e.,*

$$3)\ C = C_0 e^{-kl}$$

In this case, the concentration is the areal concentration in $kg \cdot ha^{-1}$ and l is the distance from the edge of the field and k is in units of reciprocal distance, l^{-1}, rather than reciprocal time. A related model with somewhat more flexibility which thus fits better to many data sets which are not exactly first-order in behavior is the indeterminate order model.

$$4)\ \frac{dC}{dl} = -kC^n$$

Where the order of the model n, is a variable parameter, and can be used to adjust the curvature of the line to more precisely fit decline curves. This is the same equation as IORE (Indeterminate Order Rate Equation) currently used by EFED for estimating degradation rate kinetics for soil and aquatic metabolism studies. To integrate this differential equation, it first must rearranged to separate the variables across the equal sign:

$$5)\ \frac{dC}{C^n} = -k\,dl$$

$$6)\ \int \frac{dC}{C^n} = -k \int dl$$

$$7)\ \frac{C^{1-n}}{1-n} = K - kl$$

Where K is constant of integration. When l = 0:

$$8)\ \frac{C_0^{1-n}}{1-n} = K - k \times 0$$

$$9)\ \frac{C_0^{1-n}}{1-n} = K$$

Where C_0 is the concentration at l = 0. Substituting this into equation 7, we get:

$$10)\ \frac{C^{1-n}}{1-n} = \frac{C_0^{1-n}}{1-n} - kl$$

We can solve this explicitly for C to get integrated form of the indeterminate order rate equation for decrease with distance.

$$11)\ C^{1-n} = C_0^{1-n} - (1-n)kl$$

$$12)\ (1-n)\ln(C) = \ln(C_0^{1-n} - (1-n)kl)$$

$$13)\ \ln(C) = \frac{\ln(C_0^{1-n} - (1-n)kl)}{(1-n)}$$

$$14)\ C = [C_0^{1-n} - kl(1-n)]^{\frac{1}{(1-n)}}$$

This can be fit to deposition-versus-distance spray drift curves using, C_0, k, and n as fitted parameters. It is also sometimes useful to know the distance from the edge of the field at which a certain concentration occurs; we can solve equation 11 for l to get:

$$15)\ l = \frac{C_0^{1-n} - C^{1-n}}{k(1-n)}$$

To calculate the mean spray drift deposition across a buffer, you need to integrate the deposition across the buffer width and divide by the width:

$$16)\ \bar{C} = \frac{\int_{l_0}^{l_f} [C_0^{1-n} - kl(1-n)]^{\frac{1}{(1-n)}} dl}{l_f - l_0}$$

We can make this problem simpler by making some substitutions:

$$17) z = 1-n,\ \ u = C_0^{1-n} - klz$$

We can also differentiate u as function of l to get:

$$18)\ \frac{du}{dl} = -kz$$

We can then solve for dl to get:

$$19)\ dl = -\frac{du}{kz}$$

Substituting equations 17 and 19 into 16 we get:

$$20)\ \bar{C} = \frac{\left(\frac{-1}{kz}\right) \int_{u_0}^{u_f} u^{\frac{1}{z}} du}{l_f - l_0}$$

Solving the integral expression we get:

$$21)\ \bar{C} = \frac{\left(1+\frac{1}{z}\right)\left(\frac{-1}{kz}\right)\left[u_f^{\left(1+\frac{1}{z}\right)} - u_0^{\left(1+\frac{1}{z}\right)}\right]}{l_f - l_0}$$

We can the back substitute expressions for u_f and u_0:

$$22)\ \bar{C} = \frac{\left(1+\frac{1}{z}\right)\left(\frac{-1}{kz}\right)\left[C_0^{1-n} - kl_f z^{\left(1+\frac{1}{z}\right)} - C_0^{1-n} + kl_0 z^{\left(1+\frac{1}{z}\right)}\right]}{l_f - l_0}$$

This can be rearranged and simplified to

$$\bar{C} = \frac{\left(\frac{z+1}{kz^2}\right)\left[kzl_0{}^{\left(1+\frac{1}{z}\right)} - \left(kzl_f\right)^{\left(1+\frac{1}{z}\right)}\right]}{l_0 - l_f}$$

The linear equilibrium partition equation for partitioning a chemical between a mass of soil and a volume of water is:

$$\text{A1)}\ K_d = \frac{C_{soil}}{C_{aq}} = \frac{\frac{m_{soil}}{M_{soil}}}{\frac{m_{aq}}{V}}$$

Where K_d is the soil-water partition coefficient, C_{soil} is the concentration of the chemical on soil, C_{aq} is the concentration of the chemical in water, m_{soil} is the mass of the pesticide on the soil, m_{aq} is the mass of the pesticide in solution, M_{soil} is the mass of the soil, and V is the volume of water. K_d, M_{soil}, and V are known constant values, whereas, m_{soil} and m_{aq} can vary.
However, in the case where the total mass of pesticide m_T is known:

$$\text{A2)}\ m_T = m_{soil} + m_{aq}$$

that is, the total mass is equal to the mass on soil plus the mass in solution.
If we solve equation 2 for m_{soil} and substitute into equation A1:

$$\text{A3)}\ K_d = \frac{C_{soil}}{C_{aq}} = \frac{\frac{m_T - m_{aq}}{M_{soil}}}{\frac{m_{aq}}{V}}$$

We can then rearrange, and solve for m_{aq},

$$\frac{K_d m_{aq}}{V} = \frac{m_T - m_{aq}}{M_{soil}}$$

$$\frac{K_d m_{aq}}{V} = \frac{m_T}{M_{soil}} - \frac{m_{aq}}{M_{soil}}$$

$$\frac{K_d m_{aq}}{V} + \frac{m_{aq}}{M_{soil}} = \frac{m_T}{M_{soil}}$$

$$\frac{K_d M_{soil} m_{aq}}{V M_{soil}} + \frac{V m_{aq}}{V M_{soil}} = \frac{m_T}{M_{soil}}$$

$$\frac{(K_d M_{soil} + V) m_{aq}}{V M_{soil}} = \frac{m_T}{M_{soil}}$$

$$\text{A4)}\ m_{aq} = \frac{m_T V}{(K_d M_{soil} + V)}$$

m_{aq}

Attachment 5. Listed species (identified using LOCATES) that co-occur with soybeans in the states relevant to this action

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Taxon Count by State for Selected Crops

Minimum of 1 Acre
All Medium Types Included

SOYBEANS FOR BEANS

Alabama, Arkansas, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Montana, Nebraska, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Wyoming

Amphibian, Arachnid, Bird, Bivalve, Conf/cycds, Coral, Crustacean, Dicot, Ferns, Fish, Gastropod, Insect, Lichen, Mammal, Monocot, Reptile

SOYBEANS FOR BEANS

	Mammal	Bird	Amphibian	Reptile	Fish	Crustacean	Bivalve	Gastropod	Arachnid	Insect	Dico	Monocot	Ferns	Conf/cycds	Coral	Lichen
Alabama	7	4	1	8	18	1	53	12		1	16	3	3			
Arkansas	3	5	1		3	1	11			1	5					
Colorado	2	7			5						4	1				
Georgia	6	3	2	6	9		14	1			17	5	2	1		
Illinois	2	3			2	1	9	1		2	6	2				
Indiana	2	2		1	1		9			2	5	1				
Iowa	1	3			3		3	1		2	3	2				
Kansas	2	5			5		3			1	1	1				
Kentucky	3	2			7	1	18				10					
Louisiana	4	4		6	3		5				2		1			
Mississippi	5	6	1	8	5		12			1	2		1			
Missouri	3	2	1		7	1	11	1		1	7	3				
Montana	3	5			3						2					
Nebraska	2	5			3		1			2	2	1				
New Mexico	1	3									1					
North Carolina	10	5		4	6		7	1	1	1	21	5				1
North Dakota	2	4			1					2		1				
Ohio	1	2		1	2		10			3	4	2				
Oklahoma	3	7			5		5			1						
Pennsylvania	1	2		1	1		7					2				
South Carolina	5	6	1	4	1		1				13	6	1			1
South Dakota	1	4			3		2			3		1				

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Tennessee	3	2			18	1	33	3	1		16	2	1			1
Texas	4	14	2	5	6	1			6	5	10	1				
Virginia	7	4	1	4	7	2	25	1	1	2	9	4				
Wyoming	3											1				

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Summary Counts of Counties, States and Species

	Mammal	Bird	Amphibian	Reptile	Fish	Crustacean	Bivalve	Gastropod	Arachnid	Insect	Dicot	Monocot	Ferns	Conf/cycds	Coral	Lichen
County Counts	1018	760	43	118	509	22	595	34	7	143	###	412	23	2		8
Species counts	23	21	8	13	57	8	87	18	7	14	75	14	5	1		1
State Counts	26	25	8	11	24	8	20	8	4	16	21	19	6	1		3

352 species with crop co-occurrence:

Smalltooth sawfish (Pristis pectinata)	Fish	Brackish, Saltwater	Alabama beach mouse (Peromyscus polionotus ammobates)	Mammal	Coastal
Perdido Key beach mouse (Peromyscus polionotus trissyllepsis)	Mammal	Coastal	Alabama (=inflated) heelsplitter (Potamilus inflatus)	Bivalve	Freshwater
Alabama cave shrimp (Palaemonias alabamae)	Crustacean	Freshwater	Alabama cavefish (Speoplatyrhinus poulsoni)	Fish	Freshwater
Alabama lampmussel (Lampsilis virescens)	Bivalve	Freshwater	Alabama moccasinshell (Medionidus acutissimus)	Bivalve	Freshwater
Alabama pearlshell (Margaritifera marrianae)	Bivalve	Freshwater	Alabama red-belly turtle (Pseudemys alabamensis)	Reptile	Freshwater
Alabama sturgeon (Scaphirhynchus suttkusi)	Fish	Freshwater	Altamaha Spinymussel (Elliptio spinosa)	Bivalve	Freshwater
Amber darter (Percina antesella)	Fish	Freshwater	Anthony's riversnail (Athearnia anthonyi)	Gastropod	Freshwater
Appalachian elktoe (Alasmidonta raveneliana)	Bivalve	Freshwater	Appalachian monkeyface (pearlymussel) (Quadrula sparsa)	Bivalve	Freshwater
Arkansas fatmucket (Lampsilis powellii)	Bivalve	Freshwater	Arkansas River shiner (Notropis girardi)	Fish	Freshwater
Armored snail (Pyrgulopsis (=Marstonia) pachyta)	Gastropod	Freshwater	Bayou darter (Etheostoma rubrum)	Fish	Freshwater
Birdwing pearlymussel (Lemiox rimosus)	Bivalve	Freshwater	Black clubshell (Pleurobema curtum)	Bivalve	Freshwater
Blackside dace (Phoxinus cumberlandensis)	Fish	Freshwater	Blue shiner (Cyprinella caerulea)	Fish	Freshwater
Bluemask (=jewel) Darter (Etheostoma sp.)	Fish	Freshwater	Bog (=Muhlenberg) turtle (Clemmys muhlenbergii)	Reptile	Freshwater
Bonytail chub (Gila elegans)	Fish	Freshwater	Boulder darter (Etheostoma wapiti)	Fish	Freshwater
Bull Trout (Salvelinus confluentus)	Fish	Freshwater	Cahaba shiner (Notropis cahabae)	Fish	Freshwater
Cape Fear shiner (Notropis mekistocholas)	Fish	Freshwater	Carolina heelsplitter (Lasmigona decorata)	Bivalve	Freshwater
Cave crayfish (Cambarus aculabrum)	Crustacean	Freshwater	Cherokee darter (Etheostoma scotti)	Fish	Freshwater
Chipola slabshell (Elliptio chipolaensis)	Bivalve	Freshwater	Choctaw bean (Villosa choctawensis)	Bivalve	Freshwater
Chucky Madtom (Noturus crypticus)	Fish	Freshwater	Clubshell (Pleurobema clava)	Bivalve	Freshwater
Colorado pikeminnow (=squawfish) (Ptychocheilus lucius)	Fish	Freshwater	Comanche Springs pupfish (Cyprinodon elegans)	Fish	Freshwater
Conasauga logperch (Percina jenkinsi)	Fish	Freshwater	Coosa moccasinshell (Medionidus parvulus)	Bivalve	Freshwater
Copperbelly water snake (Nerodia erythrogaster neglecta)	Reptile	Freshwater	Cracking pearlymussel (Hemistena lata)	Bivalve	Freshwater
Cumberland bean (pearlymussel) (Villosa trabalis)	Bivalve	Freshwater	Cumberland darter (Etheostoma susanae)	Fish	Freshwater
Cumberland elktoe (Alasmidonta atropurpurea)	Bivalve	Freshwater	Cumberland monkeyface (pearlymussel) (Quadrula intermedia)	Bivalve	Freshwater

Cumberland pigtoe (Pleurobema gibberum)	Bivalve	Freshwater	Cumberlandian combshell (Epioblasma brevidens)	Bivalve	Freshwater
Curtis pearlymussel (Epioblasma florentina curtisii)	Bivalve	Freshwater	Cylindrical lioplax (snail) (Lioplax cyclostomaformis)	Gastropod	Freshwater
Dark pigtoe (Pleurobema furvum)	Bivalve	Freshwater	Dromedary pearlymussel (Dromus dromas)	Bivalve	Freshwater
dusky gopher frog (Rana sevosa)	Amphibian	Freshwater	Duskytail darter (Etheostoma percnurum)	Fish	Freshwater
Dwarf wedgemussel (Alasmidonta heterodon)	Bivalve	Freshwater	Etowah darter (Etheostoma etowahae)	Fish	Freshwater
Fanshell (Cyprogenia stegaria)	Bivalve	Freshwater	Fat pocketbook (Potamilus capax)	Bivalve	Freshwater
Fat three-ridge (mussel) (Amblema neislerii)	Bivalve	Freshwater	Finelined pocketbook (Lampsilis altilis)	Bivalve	Freshwater
Finerayed pigtoe (Fusconaia cuneolus)	Bivalve	Freshwater	Flat pebblesnail (Lepyrium showalteri)	Gastropod	Freshwater
Flat pigtoe (Pleurobema marshalli)	Bivalve	Freshwater	Flattened musk turtle (Sternotherus depressus)	Reptile	Freshwater
Fluted kidneyshell (Ptychobranchus subtentum)	Bivalve	Freshwater	Fountain darter (Etheostoma fonticola)	Fish	Freshwater
Fuzzy pigtoe (Pleurobema strodeanum)	Bivalve	Freshwater	Georgia pigtoe (Pleurobema hanleyianum)	Bivalve	Freshwater
Goldline darter (Percina aurolineata)	Fish	Freshwater	Green blossom (pearlymussel) (Epioblasma torulosa gubernaculum)	Bivalve	Freshwater
Greenback Cutthroat trout (Oncorhynchus clarki stomias)	Fish	Freshwater	Gulf moccasinshell (Medionidus penicillatus)	Bivalve	Freshwater
Heavy pigtoe (Pleurobema taitianum)	Bivalve	Freshwater	Higgins eye (pearlymussel) (Lampsilis higginsii)	Bivalve	Freshwater
Hine's emerald dragonfly (Somatochlora hineana)	Insect	Freshwater	Houston toad (Bufo houstonensis)	Amphibian	Freshwater
Humpback chub (Gila cypha)	Fish	Freshwater	Interrupted (=Georgia) Rocksnail (Leptoxis foremani)	Gastropod	Freshwater
James spinymussel (Pleurobema collina)	Bivalve	Freshwater	Kentucky cave shrimp (Palaemonias ganteri)	Crustacean	Freshwater
Lacy elimia (snail) (Elimia crenatella)	Gastropod	Freshwater	Laurel dace (Chrosomus saylori)	Fish	Freshwater
Lee County cave isopod (Lirceus usdagalun)	Crustacean	Freshwater	Leopard darter (Percina pantherina)	Fish	Freshwater
Littlewing pearlymussel (Pegias fabula)	Bivalve	Freshwater	Louisiana pearlshell (Margaritifera hembeli)	Bivalve	Freshwater
Madison Cave isopod (Antrolana lira)	Crustacean	Freshwater	Mississippi sandhill crane (Grus canadensis pulla)	Bird	Freshwater
Narrow pigtoe (Fusconaia escambia)	Bivalve	Freshwater	Nashville crayfish (Orconectes shoupi)	Crustacean	Freshwater
Neosho madtom (Noturus placidus)	Fish	Freshwater	Neosho mucket (Lampsilis rafinesqueana)	Bivalve	Freshwater
Niangua darter (Etheostoma nianguae)	Fish	Freshwater	Northern riffleshell (Epioblasma torulosa rangiana)	Bivalve	Freshwater
Ochlockonee moccasinshell (Medionidus simpsonianus)	Bivalve	Freshwater	Orangefoot pimpleback (pearlymussel) (Plethobasus cooperianus)	Bivalve	Freshwater
Orangenacre mucket (Lampsilis perovalis)	Bivalve	Freshwater	Ouachita rock pocketbook (Arkansia wheeleri)	Bivalve	Freshwater
Oval pigtoe (Pleurobema pyriforme)	Bivalve	Freshwater	Ovate clubshell (Pleurobema perovatum)	Bivalve	Freshwater
Oyster mussel (Epioblasma capsaeformis)	Bivalve	Freshwater	Ozark cavefish (Amblyopsis rosae)	Fish	Freshwater
Ozark Hellbender (Cryptobranchus alleganiensis bishopi)	Amphibian	Freshwater	Painted rocksnail (Leptoxis taeniata)	Gastropod	Freshwater
Pale lilliput (pearlymussel) (Toxolasma cylindrellus)	Bivalve	Freshwater	Palezone shiner (Notropis albizonatus)	Fish	Freshwater
Pallid sturgeon (Scaphirhynchus albus)	Fish	Freshwater	Pink mucket (pearlymussel) (Lampsilis abrupta)	Bivalve	Freshwater

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Plicate rocksnail (Leptoxis plicata)	Gastropod	Freshwater	Purple bankclimber (mussel) (Elliptoideus sloatianus)	Bivalve	Freshwater
Purple bean (Villosa perpurpurea)	Bivalve	Freshwater	purple cat's paw (=purple cat's paw pearlymussel) (Epioblasma obliquata obliquata)	Bivalve	Freshwater
Pygmy madtom (Noturus stanauli)	Fish	Freshwater	Pygmy Sculpin (Cottus paulus (=pygmaeus))	Fish	Freshwater
Rabbitsfoot (Quadrula cylindrica cylindrica)	Bivalve	Freshwater	Rayed Bean (Villosa fabalis)	Bivalve	Freshwater
Razorback sucker (Xyrauchen texanus)	Fish	Freshwater	Red Hills salamander (Phaeognathus hubrichti)	Amphibian	Freshwater
Relict darter (Etheostoma chienense)	Fish	Freshwater	Reticulated flatwoods salamander (Ambystoma bishopi)	Amphibian	Freshwater
Ring pink (mussel) (Obovaria retusa)	Bivalve	Freshwater	Ringed map turtle (Graptemys oculifera)	Reptile	Freshwater
Roanoke logperch (Percina rex)	Fish	Freshwater	Rough hornsnail (Pleurocera foremani)	Gastropod	Freshwater
Rough pigtoe (Pleurobema plenum)	Bivalve	Freshwater	Rough rabbitsfoot (Quadrula cylindrica strigillata)	Bivalve	Freshwater
Round Ebonyshell (Fusconaia rotulata)	Bivalve	Freshwater	Round rocksnail (Leptoxis ampla)	Gastropod	Freshwater
Rush Darter (Etheostoma phytophilum)	Fish	Freshwater	San Marcos gambusia (Gambusia georgei)	Fish	Freshwater
Scaleshell mussel (Leptodea leptodon)	Bivalve	Freshwater	Scioto madtom (Noturus trautmani)	Fish	Freshwater
Sharpnose Shiner (Notropis oxyrhynchus)	Fish	Freshwater	Sheepnose Mussel (Plethobasus cyphyus)	Bivalve	Freshwater
Shenandoah salamander (Plethodon shenandoah)	Amphibian	Freshwater	Shiny pigtoe (Fusconaia cor)	Bivalve	Freshwater
Shinyrayed pocketbook (Lampsilis subangulata)	Bivalve	Freshwater	Slabside Pearlymussel (Pleuronaia dolabelloides)	Bivalve	Freshwater
Slackwater darter (Etheostoma boschungi)	Fish	Freshwater	Slender campeloma (Campeloma decampi)	Gastropod	Freshwater
Slender chub (Erimystax cahni)	Fish	Freshwater	Smalleye Shiner (Notropis buccula)	Fish	Freshwater
Smoky madtom (Noturus baileyi)	Fish	Freshwater	Snail darter (Percina tanasi)	Fish	Freshwater
Snuffbox mussel (Epioblasma triquetra)	Bivalve	Freshwater	Southern acornshell (Epioblasma othcaloogensis)	Bivalve	Freshwater
Southern clubshell (Pleurobema decisum)	Bivalve	Freshwater	Southern combshell (Epioblasma penita)	Bivalve	Freshwater
Southern kidneyshell (Ptychobranchus jonesi)	Bivalve	Freshwater	Southern pigtoe (Pleurobema georgianum)	Bivalve	Freshwater
Southern sandshell (Hamiota (=Lampsilis) australis)	Bivalve	Freshwater	Speckled pocketbook (Lampsilis streckeri)	Bivalve	Freshwater
Spectaclecase (mussel) (Cumberlandia monodonta)	Bivalve	Freshwater	Spotfin Chub (Erimonax monachus)	Fish	Freshwater
Stirrupshell (Quadrula stapes)	Bivalve	Freshwater	Sunfish, spring pygmy (Elassoma alabamae)	Fish	Freshwater
Tan riffleshell (Epioblasma florentina walkeri (=E. walkeri))	Bivalve	Freshwater	Tapered pigtoe (Fusconaia burkei)	Bivalve	Freshwater
Tar River spinymussel (Elliptio steinstansana)	Bivalve	Freshwater	Topeka shiner (Notropis topeka (=tristis))	Fish	Freshwater
Triangular Kidneyshell (Ptychobranchus greenii)	Bivalve	Freshwater	Turgid blossom (pearlymussel) (Epioblasma turgidula)	Bivalve	Freshwater
Upland combshell (Epioblasma metastriata)	Bivalve	Freshwater	Vermilion darter (Etheostoma chermocki)	Fish	Freshwater
Waccamaw silverside (Menidia extensa)	Fish	Freshwater	Watercress darter (Etheostoma nuchale)	Fish	Freshwater
White catspaw (pearlymussel) (Epioblasma obliquata perobliqua)	Bivalve	Freshwater	White wartyback (pearlymussel) (Plethobasus cicatricosus)	Bivalve	Freshwater
Winged Mapleleaf (Quadrula fragosa)	Bivalve	Freshwater	Yellow blossom (pearlymussel) (Epioblasma florentina florentina)	Bivalve	Freshwater

Yellow-blotched map turtle (Graptemys flavimaculata)	Reptile	Freshwater	Yellowfin madtom (Noturus flavipinnis)	Fish	Freshwater
Whooping crane (Grus americana)	Bird	Freshwater, Brackish	Gulf sturgeon (Acipenser oxyrinchus desotoi)	Fish	Freshwater, Saltwater
Shortnose sturgeon (Acipenser brevirostrum)	Fish	Freshwater, Saltwater	Comal Springs dryopid beetle (Stygoparnus comalensis)	Insect	Freshwater, Subterraneous
Comal Springs riffle beetle (Heterelmis comalensis)	Insect	Freshwater, Subterraneous	Grotto Sculpin (Cottus specus)	Fish	Freshwater, Subterraneous
Illinois cave amphipod (Gammarus acherondytes)	Crustacean	Freshwater, Subterraneous	Peck's cave amphipod (Stygobromus (=Stygonectes) pecki)	Crustacean	Freshwater, Subterraneous
Tumbling Creek cavesnail (Antrobia culveri)	Gastropod	Freshwater, Subterraneous	Frosted Flatwoods salamander (Ambystoma cingulatum)	Amphibian	Freshwater, Vernal Po
Finback whale (Balaenoptera physalus)	Mammal	Saltwater	Green sea turtle (Chelonia mydas)	Reptile	Saltwater
Humpback whale (Megaptera novaeangliae)	Mammal	Saltwater	North Atlantic Right Whale (Eubalaena glacialis)	Mammal	Saltwater
Sperm whale (Physeter catodon (=macrocephalus))	Mammal	Saltwater	West Indian Manatee (Trichechus manatus)	Mammal	Saltwater
Hawksbill sea turtle (Eretmochelys imbricata)	Reptile	Saltwater, Coastal	Kemp's ridley sea turtle (Lepidochelys kempii)	Reptile	Saltwater, Coastal
Leatherback sea turtle (Dermochelys coriacea)	Reptile	Saltwater, Coastal	Loggerhead sea turtle (Caretta caretta)	Reptile	Saltwater, Coastal
[Unnamed] ground beetle (Rhadine exilis)	Insect	Subterraneous	[Unnamed] ground beetle (Rhadine infernalis)	Insect	Subterraneous
Braken Bat Cave Meshweaver (Cicurina venii)	Arachnid	Subterraneous	Cokendolpher Cave Harvestman (Texella cokendolpheri)	Arachnid	Subterraneous
Government Canyon Bat Cave Meshweaver (Cicurina vespera)	Arachnid	Subterraneous	Government Canyon Bat Cave Spider (Neoleptoneta microps)	Arachnid	Subterraneous
Gray bat (Myotis grisescens)	Mammal	Subterraneous	Helotes mold beetle (Batrisodes venyivi)	Insect	Subterraneous
Madla's Cave Meshweaver (Cicurina madla)	Arachnid	Subterraneous	Ozark big-eared bat (Corynorhinus (=Plecotus) townsendii ingens)	Mammal	Subterraneous
Robber Baron Cave Meshweaver (Cicurina baronia)	Arachnid	Subterraneous	Virginia big-eared bat (Corynorhinus (=Plecotus) townsendii virginianus)	Mammal	Subterraneous
American burying beetle (Nicrophorus americanus)	Insect	Terrestrial	Attwater's greater prairie-chicken (Tympanuchus cupido attwateri)	Bird	Terrestrial
Bachman's warbler (=wood) (Vermivora bachmanii)	Bird	Terrestrial	Black-capped Vireo (Vireo atricapilla)	Bird	Terrestrial
Black-footed ferret (Mustela nigripes)	Mammal	Terrestrial	Braun's rock-cress (Arabis perstellata)	Dicot	Terrestrial
Canada Lynx (Lynx canadensis)	Mammal	Terrestrial	Carolina northern flying squirrel (Glaucomys sabrinus coloratus)	Mammal	Terrestrial
Dakota Skipper (Hesperia dacotae)	Insect	Terrestrial	DeBeque phacelia (Phacelia submutica)	Dicot	Terrestrial
Delmarva Peninsula fox squirrel (Sciurus niger cinereus)	Mammal	Terrestrial	Eastern indigo snake (Drymarchon corais couperi)	Reptile	Terrestrial
Eskimo curlew (Numenius borealis)	Bird	Terrestrial	Fleshy-Fruit Gladecress (Leavenworthia crassa)	Dicot	Terrestrial
Georgia rockcress (Arabis georgiana)	Dicot	Terrestrial	Golden-cheeked warbler (=wood) (Dendroica chrysoparia)	Bird	Terrestrial
Gopher tortoise (Gopherus polyphemus)	Reptile	Terrestrial	Gray wolf (Canis lupus)	Mammal	Terrestrial
Grizzly bear (Ursus arctos horribilis)	Mammal	Terrestrial	Gulf Coast jaguarundi (Herpailurus (=Felis) yagouaroundi cacomitli)	Mammal	Terrestrial

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Gunnison sage-grouse (Centrocercus minimus)	Bird	Terrestrial	Iowa Pleistocene snail (Discus macclintocki)	Gastropod	Terrestrial
Ivory-billed woodpecker (Campephilus principalis)	Bird	Terrestrial	Karner blue butterfly (Lycaeides melissa samuelis)	Insect	Terrestrial
Kentucky glade cress (Leavenworthia exigua laciniata)	Dicot	Terrestrial	Kirtland's Warbler (Setophaga kirtlandii)	Bird	Terrestrial
Least tern (Sterna antillarum)	Bird	Terrestrial	Lesser Prairie-Chicken (Tympanuchus pallidicinctus)	Bird	Terrestrial
Louisiana black bear (Ursus americanus luteolus)	Mammal	Terrestrial	Mexican spotted owl (Strix occidentalis lucida)	Bird	Terrestrial
Mitchell's satyr Butterfly (Neonympha mitchellii mitchellii)	Insect	Terrestrial	New Mexico meadow jumping mouse (Zapus hudsonius luteus)	Mammal	Terrestrial
noonday globe (Patera clarki nantahala)	Gastropod	Terrestrial	Northeastern beach tiger beetle (Cicindela dorsalis dorsalis)	Insect	Terrestrial
Northern aplomado falcon (Falco femoralis septentrionalis)	Bird	Terrestrial	Ocelot (Leopardus (=Felis) pardalis)	Mammal	Terrestrial
Painted snake coiled forest snail (Anguispira picta)	Gastropod	Terrestrial	Piping Plover (Charadrius melodus)	Bird	Terrestrial
Poweshiek skipperling (Oarisma poweshiek)	Insect	Terrestrial	Preble's meadow jumping mouse (Zapus hudsonius preblei)	Mammal	Terrestrial
Red wolf (Canis rufus)	Mammal	Terrestrial	Red-cockaded woodpecker (Picoides borealis)	Bird	Terrestrial
Roseate tern (Sterna dougallii dougallii)	Bird	Terrestrial	Royal marstonia (snail) (Pyrgulopsis ogmorhaphe)	Gastropod	Terrestrial
Saint Francis' satyr butterfly (Neonympha mitchellii francisci)	Insect	Terrestrial	Salt Creek Tiger beetle (Cicindela nevadica lincolniana)	Insect	Terrestrial
Short's bladderpod (Physaria globosa)	Dicot	Terrestrial	Southwestern willow flycatcher (Empidonax traillii extimus)	Bird	Terrestrial
Spruce-fir moss spider (Microhexura montivaga)	Arachnid	Terrestrial	Texas Golden Gladecress (Leavenworthia texana)	Dicot	Terrestrial
Tulotoma snail (Tulotoma magnifica)	Gastropod	Terrestrial	Virginia fringed mountain snail (Polygyriscus virginianus)	Gastropod	Terrestrial
Whorled Sunflower (Helianthus verticillatus)	Dicot	Terrestrial	Wood stork (Mycteria americana)	Bird	Terrestrial
Yellow-Billed Cuckoo (Coccyzus americanus)	Bird	Terrestrial	Rufa Red Knot (Calidris canutus rufa)	Bird	Terrestrial, Coastal
Salado salamander (Eurycea chisholmensis)	Amphibian	Terrestrial, Freshwater	Indiana bat (Myotis sodalis)	Mammal	Terrestrial, Subterraneous
Alabama canebrake pitcher-plant (Sarracenia rubra alabamensis)	Dicot	Unattributed Wetland Status	Alabama leather flower (Clematis socialis)	Dicot	Unattributed Wetland Status
Alabama streak-sorus fern (Thelypteris pilosa var. alabamensis)	Ferns	Unattributed Wetland Status	American hart's-tongue fern (Asplenium scolopendrium var. americanum)	Ferns	Unattributed Wetland Status
Black lace cactus (Echinocereus reichenbachii var. albertii)	Dicot	Unattributed Wetland Status	Blowout penstemon (Penstemon haydenii)	Dicot	Unattributed Wetland Status
Blue Ridge goldenrod (Solidago spithamaea)	Dicot	Unattributed Wetland Status	Colorado Butterfly plant (Gaura neomexicana var. coloradensis)	Dicot	Unattributed Wetland Status
Colorado hookless Cactus (Sclerocactus glaucus)	Dicot	Unattributed Wetland Status	Cumberland sandwort (Arenaria cumberlandensis)	Dicot	Unattributed Wetland Status
Decurrent false aster (Boltonia decurrens)	Dicot	Unattributed Wetland Status	Dwarf-flowered heartleaf (Hexastylis naniflora)	Dicot	Unattributed Wetland Status
Florida torreya (Torreya taxifolia)	Conf/cycds	Unattributed Wetland Status	Fringed campion (Silene polypetala)	Dicot	Unattributed Wetland Status
Gentian pinkroot (Spigelia gentianoides)	Dicot	Unattributed Wetland Status	Golden sedge (Carex lutea)	Monocot	Unattributed Wetland Status

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Guthrie's (=Pyne's) ground-plum (Astragalus bibullatus)	Dicot	Unattributed Wetland Status	Hairy rattleweed (Baptisia arachnifera)	Dicot	Unattributed Wetland Status
Heller's blazingstar (Liatris helleri)	Dicot	Unattributed Wetland Status	Holy Ghost ipomopsis (Ipomopsis sancti-spiritus)	Dicot	Unattributed Wetland Status
Lakeside daisy (Hymenoxys herbacea)	Dicot	Unattributed Wetland Status	Large-flowered skullcap (Scutellaria montana)	Dicot	Unattributed Wetland Status
Large-fruited sand-verbena (Abronia macrocarpa)	Dicot	Unattributed Wetland Status	Leafy prairie-clover (Dalea foliosa)	Dicot	Unattributed Wetland Status
Lyrate bladderpod (Lesquerella lyrata)	Dicot	Unattributed Wetland Status	Mead's milkweed (Asclepias meadii)	Dicot	Unattributed Wetland Status
Michaux's sumac (Rhus michauxii)	Dicot	Unattributed Wetland Status	Missouri bladderpod (Physaria filiformis)	Dicot	Unattributed Wetland Status
Morefield's leather flower (Clematis morefieldii)	Dicot	Unattributed Wetland Status	Mountain golden heather (Hudsonia montana)	Dicot	Unattributed Wetland Status
Mountain sweet pitcher-plant (Sarracenia rubra ssp. jonesii)	Dicot	Unattributed Wetland Status	Navasota ladies'-tresses (Spiranthes parksii)	Monocot	Unattributed Wetland Status
No common name (Geocarpon minimum)	Dicot	Unattributed Wetland Status	North Park phacelia (Phacelia formosula)	Dicot	Unattributed Wetland Status
Northern wild monkshood (Aconitum noveboracense)	Dicot	Unattributed Wetland Status	Persistent trillium (Trillium persistens)	Monocot	Unattributed Wetland Status
Pitcher's thistle (Cirsium pitcheri)	Dicot	Unattributed Wetland Status	Prairie bush-clover (Lespedeza leptostachya)	Dicot	Unattributed Wetland Status
Price's potato-bean (Apios priceana)	Dicot	Unattributed Wetland Status	Relict trillium (Trillium reliquum)	Monocot	Unattributed Wetland Status
Roan Mountain bluet (Hedyotis purpurea var. montana)	Dicot	Unattributed Wetland Status	Rock gnome lichen (Gymnoderma lineare)	Lichen	Unattributed Wetland Status
Running buffalo clover (Trifolium stoloniferum)	Dicot	Unattributed Wetland Status	Ruth's golden aster (Pityopsis ruthii)	Dicot	Unattributed Wetland Status
Schweinitz's sunflower (Helianthus schweinitzii)	Dicot	Unattributed Wetland Status	Shale barren rock cress (Arabis serotina)	Dicot	Unattributed Wetland Status
Short's goldenrod (Solidago shortii)	Dicot	Unattributed Wetland Status	Smooth coneflower (Echinacea laevigata)	Dicot	Unattributed Wetland Status
South Texas ambrosia (Ambrosia cheiranthifolia)	Dicot	Unattributed Wetland Status	Spalding's Catchfly (Silene spaldingii)	Dicot	Unattributed Wetland Status
Spreading avens (Geum radiatum)	Dicot	Unattributed Wetland Status	Spring Creek bladderpod (Lesquerella perforata)	Dicot	Unattributed Wetland Status
Star cactus (Astrophytum asterias)	Dicot	Unattributed Wetland Status	Texas ayenia (Ayenia limitaris)	Dicot	Unattributed Wetland Status
Tobusch fishhook cactus (Sclerocactus brevihamatus ssp. tobuschii)	Dicot	Unattributed Wetland Status	Walker's manioc (Manihot walkerae)	Dicot	Unattributed Wetland Status

Western prairie fringed Orchid (Platanthera praeclara)	Monocot	Unattributed Wetland Status	White irisette (Sisyrinchium dichotomum)	Monocot	Unattributed Wetland Status
White-haired goldenrod (Solidago albopilosa)	Dicot	Unattributed Wetland Status	American chaffseed (Schwalbea americana)	Dicot	Wetland
Black spored quillwort (Isoetes melanospora)	Ferns	Wetland	Bunched arrowhead (Sagittaria fasciculata)	Monocot	Wetland
Canby's dropwort (Oxypolis canbyi)	Dicot	Wetland	Cooley's meadowrue (Thalictrum cooleyi)	Dicot	Wetland
Cumberland rosemary (Conradina verticillata)	Dicot	Wetland	Eastern prairie fringed orchid (Platanthera leucophaea)	Monocot	Wetland
Green pitcher-plant (Sarracenia oreophila)	Dicot	Wetland	Harperella (Ptilimnium nodosum)	Dicot	Wetland
Kral's water-plantain (Sagittaria secundifolia)	Monocot	Wetland	Little amphianthus (Amphianthus pusillus)	Dicot	Wetland
Louisiana quillwort (Isoetes louisianensis)	Ferns	Wetland	Mat-forming quillwort (Isoetes tegetiformans)	Ferns	Wetland
Miccosukee gooseberry (Ribes echinellum)	Dicot	Wetland	Mohr's Barbara button (Marshallia mohrii)	Dicot	Wetland
Northeastern bulrush (Scirpus ancistrochaetus)	Monocot	Wetland	Pondberry (Lindera melissifolia)	Dicot	Wetland
Rough-leaved loosestrife (Lysimachia asperulaefolia)	Dicot	Wetland	Seabeach amaranth (Amaranthus pumilus)	Dicot	Wetland
Sensitive joint-vetch (Aeschynomene virginica)	Dicot	Wetland	Small whorled pogonia (Isotria medeoloides)	Monocot	Wetland
Small-anthered bittercress (Cardamine micranthera)	Dicot	Wetland	Swamp pink (Helonias bullata)	Monocot	Wetland
Tennessee yellow-eyed grass (Xyris tennesseensis)	Monocot	Wetland	Texas prairie dawn-flower (Hymenoxys texana)	Dicot	Wetland
Ute ladies'-tresses (Spiranthes diluvialis)	Monocot	Wetland	Virginia sneezeweed (Helenium virginicum)	Dicot	Wetland
Virginia spiraea (Spiraea virginiana)	Dicot	Wetland	Water howellia (Howellia aquatilis)	Dicot	Wetland

No species were selected for exclusion.

Marine Species

Aquatic Marine Listing

Coral (Acroporidae)

Name		Water Body	
coral (ncn)	*Acropora spinosa*	Indo-Pacific	
Elkhorn coral	*Acropora palmata*	Caribbean	Gulf of Mexico
Staghorn coral	*Acropora cervicornis*	Caribbean	

Coral (Agariciidae)

Name		Water Body
coral (ncn)	*Pavona diffluens*	Indo-Pacific

Coral (Euphyllidae)

Name		Water Body

coral (ncn)	*Euphyllia paradivisa*	Indo-Pacific	

Coral (Faviidae)

Name		Water Body	
Boulder star coral	*Orbicella franksi*	Caribbean	Gulf of Mexico
Lobed Star Coral	*Orbicella annularis*	Caribbean	Gulf of Mexico
Mountainous Star Coral	*Orbicella faveolata*	Caribbean	Gulf of Mexico

Coral (Meandrinidae)

Name		Water Body	
Pillar Coral	*Dendrogyra cylindricus*	Caribbean	

Coral (Mussidae)

Name		Water Body	
Rough Cactus Coral	*Mycetophyllia ferox*	Caribbean	Gulf of Mexico

Coral (Pocilloporidae)

Name		Water Body	
coral (ncn)	*Seriatopora aculeata*	Indo-Pacific	

Coral (Poritidae)

Name		Water Body	
coral (ncn)	*Porites napopora*	Indo-Pacific	

Fish (Scorpaenidae)

Name		Water Body	
Canary rockfish	*Sebastes pinniger*	Puget Sound	
Rockfish, Yelloweye	*Sebastes ruberrimus*	Puget Sound	

Gastropod (Haliotidae)

Name		Water Body	
Abalone, Black	*Haliotis cracherodii*	Pacific	

Mammal (Balaenidae)

Name		Water Body	
North Atlantic Right Whale	*Eubalaena glacialis*	Atlantic	
Whale, bowhead	*Balaena mysticetus*		Pacific
Whale, North Pacific right	*Eubalaena japonica*	Pacific	

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Mammal (Balaenopteridae)

Name		Water Body		
Blue whale	*Balaenoptera musculus*	Atlantic	Pacific	
Finback whale	*Balaenoptera physalus*	Atlantic	Pacific	
Humpback whale	*Megaptera novaeangliae*	Atlantic	Pacific	
Sei whale	*Balaenoptera borealis*	Atlantic	Pacific	

Mammal (Cervidae)

Name		Water Body		
Killer whale	*Orcinus orca*	Puget Sound		

Mammal (Delphinidae)

Name		Water Body		
False killer whale	*Pseudorca crassidens*	Atlantic	Pacific	

Mammal (Eschrichtiidae)

Name		Water Body		
Whale, Gray	*Eschrichtius robustus*	Beaufort Sea	Bering Sea	Chukchi Sea

Mammal (Phocidae)

Name		Water Body		
Beluga Whale	*Delphinapterus leucas*	Cook Inlet		
Seal, bearded (Atlantic)	*Erignathus barbatus barbatu*	Arctic Ocean		
Seal, bearded (Pacific)	*Erignathus barbatus nauticus*	Arctic Ocean	Sea of Okhotsk	
Seal, Hawaiian Monk	*Neomonachus schauinslandi*	Pacific		
Seal, ringed (Arctic)	*Phoca hispida hispida*			
Seal, ringed (Baltic)	*Phoca hispida botnica*	Arctic Ocean		
Seal, ringed (Ladoga)	*Phoca hispida ladogensis*	Arctic Ocean		
Seal, ringed (Okhotsk)	*Phoca hispida ochotensis*	Arctic Ocean		
Seal, spotted	*Phoca largha*	Arctic Ocean	Pacific	Sea of Okhotsk

Mammal (Physeteridae)

Name		Water Body		
Sperm whale	*Physeter catodon (=macroce*	Atlantic	Gulf of Mexico	Pacific

Monocot (Hydrocharitaceae)

Name		Water Body			
Johnson's seagrass	*Halophila johnsonii*	Atlantic			

Reptile (Cheloniidae)

Name		Water Body			
Green sea turtle	*Chelonia mydas*	Atlantic	Caribbean	Gulf of Mexico	Pacific
Hawksbill sea turtle	*Eretmochelys imbricata*	Atlantic	Caribbean	Gulf of Mexico	
Kemp's ridley sea turtle	*Lepidochelys kempii*	Atlantic	Caribbean	Gulf of Mexico	
Loggerhead sea turtle	*Caretta caretta*	Atlantic	Caribbean	Gulf of Mexico	Pacific
Olive ridley sea turtle	*Lepidochelys olivacea*	Pacific			

Reptile (Dermochelyidae)

Name		Water Body			
Leatherback sea turtle	*Dermochelys coriacea*	Atlantic	Caribbean	Gulf of Mexico	Pacific